Aalborg Universitet

A Research-based Curriculum for Cadastral Studies

Stubkjær, Erik

Published in:
Scientia Est Potentia

Publication date:
2007

Document Version
Publisher's PDF, also known as Version of record

Link to publication from Aalborg University

Citation for published version (APA):
Stubkjær, E. (2007). A Research-based Curriculum for Cadastral Studies. In A. Cepek (Ed.), *Scientia Est Potentia: Knowledge is Power : proceedings of the symposium dedicated to the development of curricula organized jointly by FIG Commission 2 and the Faculty of Civil Engineering CTU in Prague* (pp. 135-145). Faculty of Civil Engineering, CTU.

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal -

Take down policy
If you believe that this document breaches copyright please contact us at vbn@aub.aau.dk providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from vbn.aau.dk on: May 06, 2023

Czech Technical University in Prague

Scientia Est Potentia

Knowledge is Power

**Proceedings of the symposium dedicated to
the development of curricula
organized jointly by FIG Commission 2 and
the Faculty of Civil Engineering CTU in Prague**

Aleš Čepek (Ed.)

Prague, 7-9 June 2007

Scientific Committee

Chairman: Béla Márkus, Hungary
Secretary: Aleš Čepek, Czech Republic
Members: Pedro Cavero, Spain; Stig Enemark, Denmark; Liza Groenendijk, The Netherlands; Ján Hefty, Slovakia; Jiří Horák, Czech Republic; Jan Kolář, Czech Republic; Milan Konečný, Czech Republic; Alojz Kopáčik, Slovakia; Reinfried Mansberger, Austria; Leoš Mervart, Czech Republic; Paul van der Molen, The Netherlands; Esben Munk Sorensen, Denmark; Andras Ossko, Hungary; Chryssy Potsiou, Greece; Markéta Potůčková, Czech Republic; Petr Rapant, Czech Republic; Rudolf Staiger, Germany; Gert Steinkellner, Austria; Jiří Šíma, Czech Republic; Václav Talhofer, Czech Republic; Bohuslav Veverka, Czech Republic; Kauko Viitanen, Finland; Arvo Vitikainen, Finland; Vít Voženílek, Czech Republic; Josef Weigel, Czech Republic; Růžena Zimová, Czech Republic; Vladimír Židek, Czech Republic.

Organizing Committee

Chairman: Aleš Čepek, Czech Republic
Co-Chair: Jancsó Tamás, Hungary
Members: Lena Halounová, Czech Republic; Martin Landa, Czech Republic; Jiří Pospíšil, Czech Republic; Jan Pytel, Czech Republic; Martin Štroner, Czech Republic.

Editor Aleš Čepek

Papers were anonymously reviewed by the members of the scientific committee.

Prague, June 2007

ISBN 978-80-01-03718-8

This book was prepared from the input files supplied by the authors. No additional English style correction of the included articles were made by the compositor.

Published by the Czech Technical University in Prague. Printed by CTU Publishing House.

Jozeff z Božij milosti wolený Rzijmský Cýsarž, po-
wssecky czasy Rozmnožitel Rzijsse, Vherský, a Cžeský Kral.

Wysocze Urozenij, a Stateczný, Wiernij Mili:
Tegna Wám neczinijme, kterak se t Slawné
a Swaté Pamieti Cýsarži Leopoldowi toho
gmena Prwnijmu, Panu Otczy Nassemu Neij-
milegssijmu, Krystyan Jozeff Willenberg
Ingenieur, sub praesentato Trzidcžátého dne
Mieśycze Ledna, minulého Sedumnácztystého
Pátého Leta, dle tuto wnyzpsanie przileżiczýho
poniżeného Supplikwého w Cžeském Jazyku, po-
slussnie byl ukazel, a zato, by mu od Wiernijch
a poslussnijch Stawuow Nassich w Kralowstwij
Nassem dieditzném Cžeském, gisty Roczni Plat,
proti Wyuczowanij w Kunstu Ingenierskem
Mladeže Wyssiho a Miestského Stawu, wyměřen
a až do żiwobytí geho wydawan byl, poniżenie
prosyl; A by wsse geho poslédawáni od Kra-
lowské Canczellarže Nassi Cžeské Dworské

Naši Czeské dworské relationirowati, a tak na
tom milostiwau wůli Naši Czysařzskau a Krá-
lowskau poslušnie naplniti nepominete. Zů-
stawage Wam przitom milosti Naši Czysařzskau
a Králowskau naklonienj. Dan w Miestie Našem
Wjdnj, Čtrnácztého dne Miesýcze Ledna, Leta
Páně Sedůmnácztistého Sedmého, Králowstwj
Našich, Ržjmského Sedůmnácztého, Uherského
Dwadczátého, a Czeského druhého.

Josephus

Wenceslaus Norbertus Kinsky
Regni Boemiae supremus Cancellarius

Jo. Wratislaw

Ad mandatum Sac. Caes.
Regiaeque Maiestatis proprium.

J. W. Z. Walbourg

Foreword

The Latin phrase Scientia Est Potentia (Knowledge Is Power) was selected as a motto of the symposium organized jointly by FIG Commission 2 and Faculty of Civil Engineering Czech Technical University in Prague on the occasion of the 300th anniversary of the Czech Technical University in Prague. The symposium is dedicated to the development of curricula in geoinformatics, surveying, geodesy and cartography.

The origination of a public engineering education in Bohemia, Moravia and Silesia was initiated by Christian Josef Willenberg (1650–1731). He addressed his petition in Czech to the Emperor Leopold I in January 1705. Willenberg, 35 years old, was experienced in preceptorship and teaching in aristocratic families, mainly in Bohemia and France.

After passing examinations in arithmetic, geometry, trigonometry and fortification of an irregular area, the Court Council awarded him the Emperor's Engineer title in 1706. The Emperor Josef I supported Willenberg's idea by a transcript of 18 January 1707. Two pages of the transcript are shown on the previous pages. We consider 18 January 1707 the day of foundation of ČVUT (the Czech Technical University).

We are organizing our symposium as a part of the CTU celebrations to the tribute of Willenberg and technical education, taking place in Bohemia, Moravia and Silesia for the continuous period of 300 years.

Aleš Čepek

Contents

Renewing the Geomatics Engineering Undergraduate Curriculum at the University of New Brunswick

David J. COLEMAN, Peter DARE, Canada

Key words: geomatics engineering, education, curriculum, professional accreditation, land surveying

SUMMARY

The evolution of the Geomatics Engineering curriculum at the University of New Brunswick (UNB) over the past forty-five years reflects both: (1) the growth and evolution of Canada's geomatics profession as a whole; and (2) society's demands for a broader and more balanced education in professional engineering and surveying. UNB's new 4-year BScE program and our concurrent degree program with Computer Science both reflect our latest thinking in terms of the depth and range of geomatics material, the mix between lectures and hands-on projects, and a strong focus on options for formal Co-Op employment and/or international exchanges. Given the increasingly rapid changes being experienced today — and seeing how they are affecting the way traditional and new employers alike can succeed — we expect the strong demand for our graduates to continue well into the future.

1. INTRODUCTION

Originally started as the Surveying Engineering program in 1960, the Department of Geodesy and Geomatics Engineering's first class of undergraduates finished their degree in 1962. Over the past forty-five years, almost 1200 students from over 50 countries have graduated from the Department's Bachelors, Masters and PhD programs after making their own unique contributions to university life on the UNB campus in Fredericton, New Brunswick. These students have gone onto rewarding careers in cadastral surveying, geodesy and GPS, photogrammetry, engineering and mining surveying, geographic information systems, land administration and ocean mapping.

While originally established through the vision and persistence of several leading professional surveyors, mappers, and educators in New Brunswick, neither the research agenda nor the curriculum of the Department has ever been tied purely to the needs of any one particular professional group in any one region of Canada. Similarly, the curriculum content and standards have often gone well beyond -- and sometimes in a different direction than – the needs initially expressed by members of professional surveying and engineering bodies in Canada. That said, the undergraduate program must continue to meet at least the needs and standards of *three* different accrediting bodies – the Canadian Engineering Accreditation Board (CEAB), the Canadian Council of Land Surveyors (CCLS), and the Royal Institution of Chartered Surveyors (RICS).

The undergraduate curriculum has evolved over the years, with minor modifications to individual courses and specific streams taking place on a regular basis. Every decade or so, however, more substantial curriculum-wide changes have been undertaken which affect the overall program, the relationships between different streams, and overall learning outcomes.

In this paper, the authors describe the efforts made by Department faculty over the past 24 months to update and revise the UNB Geomatics Engineering undergraduate curriculum. After introducing the demographics of the Department and a brief summary of the current curriculum, the authors discuss the drivers causing a re-examination of the curriculum at this time. The paper concludes with a description of the detail and rationale for the proposed changes and plans for future revisions.

2. GEODESY AND GEOMATICS ENGINEERING AT UNB

2.1 Brief History, Faculty/Student Demographics & Statistics on Enrolment

The Department of Geodesy and Geomatics Engineering (GGE) is the smallest and newest of 5 Departments in the UNB Faculty of Engineering. It offers programs and research in the fields of cadastral surveying, geodesy and GPS, engineering and mining surveying, geographic information systems, land administration and ocean mapping. Founded in 1962 as the Department of Surveying Engineering, the Department's current student enrollment ranges between 110-120 undergraduate and 55-60 post-graduate students, with 9 faculty members, 7 research staff, and 7 technical and administrative support staff.

Through the 1960s and early 1970s, the undergraduate program attracted a mix of direct-entry high school students, mature students already involved in surveying or mapping, and international students funded by their governments. Students typically took the first 3 years of courses in Civil Engineering or Forestry before taking their final two years of specialization in what was then known as Surveying Engineering. Graduates typically worked for government agencies, utilities, and private companies involved in the creation and management of large control survey networks and base mapping programs. Very few graduates worked for small surveying firms.

Until the late 1970s in most Canadian provinces, professional land surveyors came from a variety of backgrounds and obtained their licenses through a series of examinations followed by an apprenticeship period. More stringent formal education requirements for Canadian land surveyors began being proposed in the 1950s (e.g., Blachut [1957]). New criteria for education and professional entrance requirements were discussed in three separate Canadian Institute of Surveying conferences on surveying education held in 1959, 1966 and 1977. By the mid-1970s, most provinces were re-examining educational requirements for professional land surveyors [Dobbin, 1999]. In 1975, a special report to the Maritime Provinces Higher Education Commission of the Council of Maritime Premiers recommended that bachelor's level university education (or equivalent) was the minimum level of education required for individuals entering the Land Surveying profession [Love, 1975]. This created a significant new market – and a different student clientele – for the UNB program.
Today, approximately 60% of the undergraduate students come from Atlantic Canada, with the remainder coming from elsewhere in the country and overseas. Roughly half of the undergraduate students in the Geomatics Engineering program have completed previous geomatics diplomas at such community colleges as the Centre for Geographic Sciences in

Nova Scotia, the College of the North Atlantic in Newfoundland, the Red River College in Manitoba, and the British Columbia Institute of Technology. For many years, the Department has been home to a larger number of international postgraduate students than many *faculties* on campus. Since 1961, well over 400 international students from more than 50 countries have obtained degrees in Surveying or Geomatics Engineering from UNB.

A full description of the programs, faculty, research and publications is available on the Web at URL *http://gge.unb.ca*.

2.2 Accreditation Requirements

As a program providing the education for engineers and professional land surveyors intending to work in any part of Canada and beyond, the Department deals with the accreditation requirements of 3 different professional bodies. UNB's B.Sc.E. in Geomatics Engineering degree program is currently accredited by the Canadian Council of Professional Engineers (through the Canadian Engineering Accreditation Board), the Canadian Council of Land Surveyors, and the Royal Institution of Chartered Surveyors.

2.2.1 Canadian Engineering Accreditation Board (CEAB)

The CEAB was established by the Canadian Council of Professional Engineers in 1965 to *"…accredit undergraduate engineering programs which provide aspiring engineers with the academic requirements necessary for registration as a professional engineer in Canada"* [CEAB, 2007]. Conducted once every 6 years, a 3-day CEAB site visit involves months of advance preparation and substantial documentation for each program under review. The Board's accreditation process is "input-oriented", assessing each and every course contained in a given program in terms of its relative Basic Mathematics and Science, Complementary Studies, Engineering Science and Engineering Design content in accordance with CEAB guidelines and criteria. Site visitors apply "minimum-path" criteria to ensure that even the quickest and shortest route through a given program meets the minimum requirements.

A copy of CEAB's 2006 Annual Report and supporting documents may be found on-line a *http://www.ccpe.ca/e/prog_publications_3.cfm*. CEAB's guidelines have ensured that virtually every university undergraduate engineering program offered in Canada is of a uniformly high standard. According to the 1999 edition of *The Gourman Report* [1999] (admittedly now dated), almost all of Canada's engineering programs at the time were ranked in the top 30% of North American university engineering programs. On the other hand, ensuring a program meets certain minimum criteria for engineering science and design can sometimes stifle innovation – particularly in times when there is disagreement over what should be included in a discipline like geomatics engineering. At present, only two Canadian universities operate CEAB-accredited Geomatics Engineering programs – UNB and the University of Calgary.

2.2.2 Canadian Council of Land Surveyors (CCLS)

One of the functions of the Canadian Council of Land Surveyors (CCLS) is to set minimum national entrance educational standards for applicants to land surveying licensing authorities.

Self-governing provincial associations grant licenses to applicants who wish to qualify as a Land Surveyor within a specific province or territory, and the Association of Canada Lands Surveyors grants licenses nationally for those applicants that wish to be able to survey Canada Lands (this includes national parks, land covered by water, and aboriginal land). CCLS carries out accreditation visits to educational institutions to ensure the program contains the content at the required level of difficulty as described in the CCLS syllabus, while one of the functions of accreditation is *"…to foster, in co-operation with the educational institutions, a high standard of surveying education in Canada."* [CCLS, 2007]. The GGE Department achieved its initial accreditation with CCLS in 1985.

CCLS requirements, like CEAB, are very content-driven and very broad -- requiring geomatics engineering students to take courses offered by the Department of Civil Engineering (Urban Planning and Site Planning) to meet their accreditation requirements. Thus our needs for accreditation places demands on other departments.

Requirements for accreditation cover the areas of curriculum, staff, student body, and physical. It is these curriculum requirements that are most relevant for this paper. *"It is expected that an accredited program will include a balanced, in depth examination of the appropriate basic sciences and mathematics, surveying and mapping technologies, social sciences and the law, management sciences and professional studies."* [CCLS, 2007]. What is "appropriate" is not explicitly specified, although CCLS has a model syllabus against which a program can be examined. To ensure the degree is appropriate, a CCLS accreditation site visit examines admission standards, degree content, contact hours, assignments, examinations, and both student and industry feedback. Like the CEAB process, weeks of advance preparation are required.

2.2.3 Royal Institution of Chartered Surveyors

The Royal Institution of Chartered Surveyors (RICS) had a very similar accreditation method to that used by CCLS and CEAB until the late 1990s (i.e., content-driven and requiring weeks of preparation). At that time RICS started to slowly rollout from the UK a new accreditation method based upon the meeting of four threshold standards (entry, employment, teaching quality, and research). Successfully passing the set thresholds enables a "Partnership" between RICS and the degree-awarding department to be created. This process does not study degree content. Instead, appropriateness for the profession is judged by a high percentage of the students completing the degree gaining relevant employment. In 2003 we were accredited under the old system (the first degree to be accredited by RICS in Canada), but we hope to convert to the new partnership system soon. Partnership demands are less on the content of the degree, but increased in the areas of the thresholds. This approach requires far less work from the university, and annual partnership meetings are carried out in a spirit of cooperation.

2.3 History of Changes to Curriculum

The evolution of the Geomatics Engineering curriculum at UNB over the past forty years reflects both: (1) the growth and evolution of the Canadian geomatics profession; and (2) the respective demands of professional associations for a broader and more balanced education in professional engineering and surveying. Figures 1 through 4 illustrate the composition of the undergraduate degree programs in 1965, 1975, 1990 and 2005 respectively.

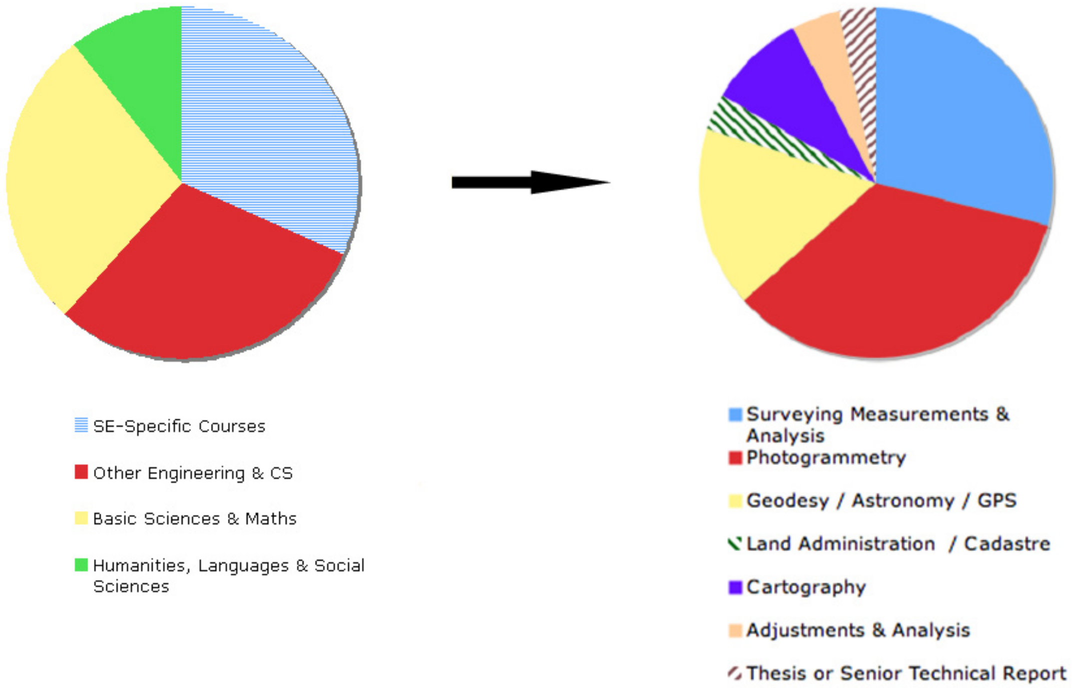


Fig. 1: 1965 Surveying Engineering Curriculum

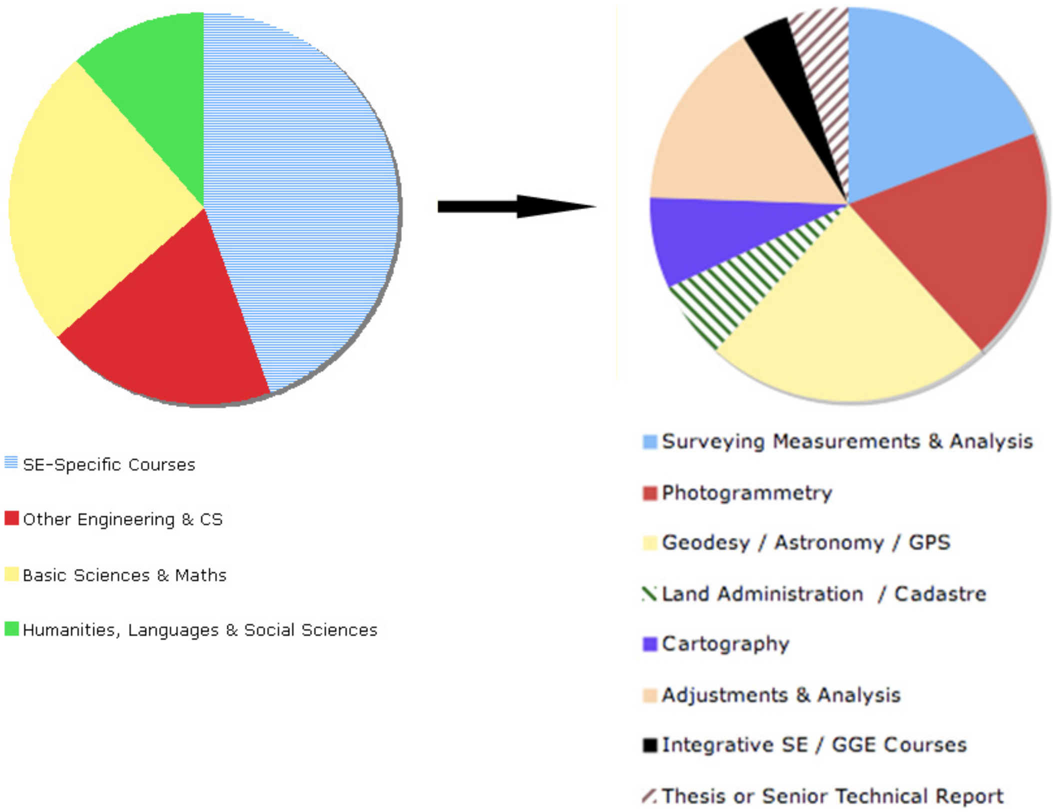


Fig. 2: 1975 Surveying Engineering Curriculum

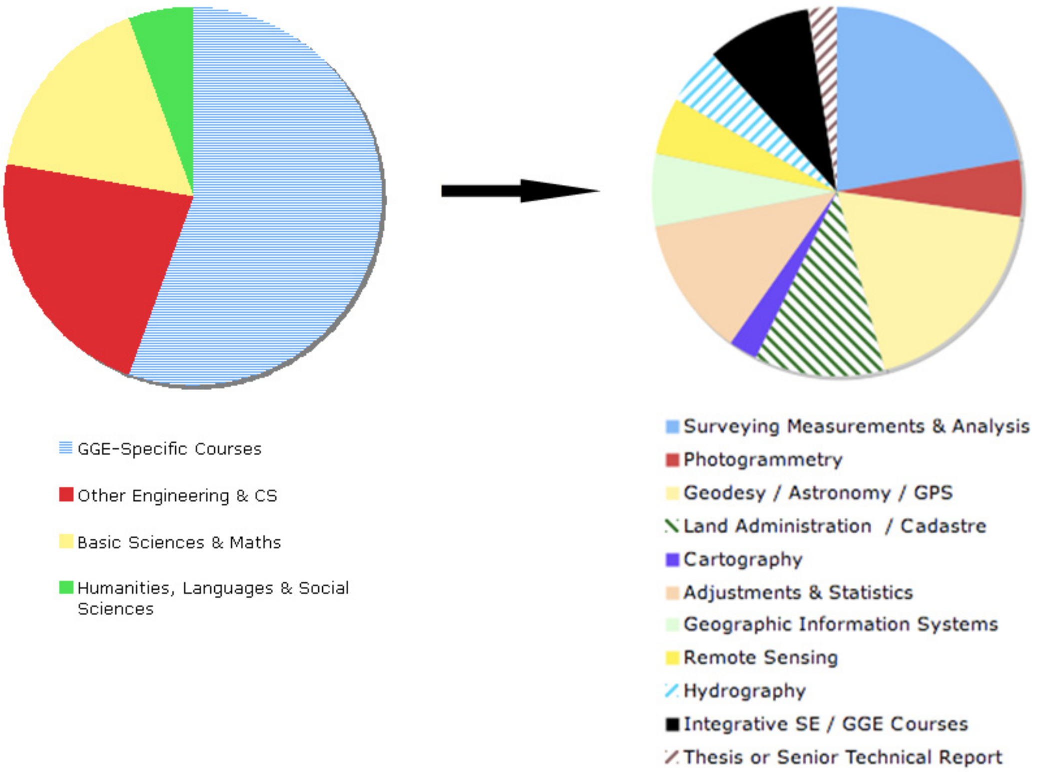


Fig. 3: 1990 Surveying Engineering Curriculum

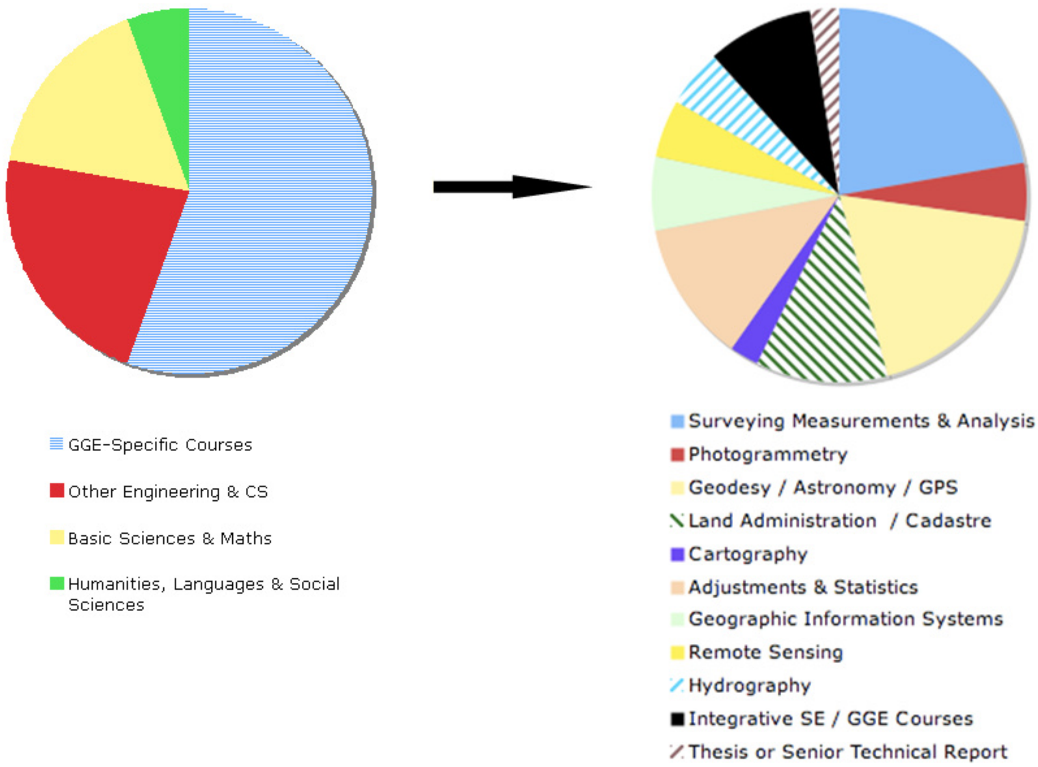


Fig 4: 2005 Geomatics Engineering Curriculum w/ Cadastral Survey Option

Figures 1 to 4 show the evolution of the program in terms of content, with special emphasis on the Cadastral Survey Option. Officially begun as a 5-year program, it remained that way until 1978. Successive versions of the program were designed in part to reduce the course load in order for the typical competent student to be able to complete the program comfortably in 4 years. However, course requirements would creep up once again in subsequent years. While the program credit hours had been reduced from 225 to 180 from 1965 through 2005, exit surveys indicated that students were still taking 5-5.5 years to complete the degree.

Through this period, three major trends may be seen:

1. the overall increase in geomatics-specific content at the expense of other components (mainly courses from other Engineering disciplines, but also from Arts and Humanities);
2. the steady reduction in the treatment of photogrammetry and production cartography – today, this field of cartography is no longer taught at all, and students are introduced to photogrammetry late in the program as a special application of remote sensing; and
3. the increase in program breadth with the steady increase in treatments of land administration, GIS, remote sensing, hydrography, and "integrative" courses which tie together and apply material taught in the different geomatics streams.

The increasing influence of CCLS accreditation is clear from the increased land administration content. The breadth of the curriculum reflects the variety of requirements now faced by different groups of professionals in Canada's geomatics community. What is also interesting is the increasing proportion of the program taught *within* the Department over the years – largely at the expense of other engineering and humanities/languages/social science courses.

This can be viewed in two ways. On the positive side, the resulting mix of courses gives the undergraduate student greater exposure to the breadth and depth of subjects which now comprise geomatics engineering. On the other hand, the reduction in external courses gives students less exposure to wider (and sometimes-contrasting) viewpoints & values offered by other courses in other departments and faculties on campus.

3. DRIVERS FOR CURRENT CHANGES

3.1 Internal and Accreditation Related

In 2004, the Faculty of Engineering at UNB began re-examining all nine undergraduate engineering programs with a view to: (1) addressing curriculum concerns raised by site visitors in the most recent accreditation visits; (2) reducing the content of all programs so an average student could realistically expect to complete all requirements in 4 years; and (3) transforming the common first-year and final-year courses to streamline and better integrate material from other courses to create a more effective engineering learning experience.

Accreditation issues in GGE raised by CEAB and CCLS visitors related mainly to: (a) targeted coverage of selected legal and business management issues associated with land surveying; (b) paying more attention to open-ended engineering design issues -- an interesting challenge in geomatics engineering; and (c) devoting greater attention to the senior technical report and the design project undertaken by individual students.

Program length had become an issue. As with many technology-based professional programs, new content had been added over the years but very little had been removed. According to exit surveys of graduating students, the average UNB Engineering student was taking 5 to 5.5 years to complete a "4-year program". Adding a formal Co-Op work term or international exchange would increase the time even further. Compared with most other Canadian universities offering engineering degrees attainable in 4 years – and at a time when university student debt loads were increasing -- UNB students were investing more without seeing any commensurate difference in salary offers from national employers.
As part of this, changes were also made to the common engineering core curriculum in order to: (a) streamline the program; (b) better integrate the basic maths, sciences and computer science courses with early engineering courses; (c) strengthen the engineering design component; and (d) introduce and integrate key "soft-skills" -- technical communications, team-building and project management – into first-year coursework and assignments.

3.2 Market Feedback

In 2006, the GGE Department engaged an external consultant to inform us on future opportunities and current perceptions of the Department, and then to provide feedback from the profession on specific issues including the curriculum. The feedback demonstrated a strong focus on one particular sector of our overall market. Delivered in January 2007, the main recommendations relevant to the curriculum included:

- Students should have additional business skills when they graduate;
- UNB's geomatics Engineering program is perceived to produce Land Surveyors, not Engineers, and this differentiation should be strengthened;
- We should teach more on modern systems for spatial data capture and visualization (e.g., laser scanners, LiDAR);
- Replace the introductory level instruction of computer programming languages (e.g., C++) with problem-solving software (e.g., MATLAB); and
- Re-form the industry advisory board.

Informal feedback from employers over the years reinforces some of these recommendations. In particular, we are constantly told to teach more business skills whilst the technical skills are at a sufficient level. In addition, of all our accreditations, it is the CCLS accreditation that currently brings the employers to UNB to hire our students. This is likely due to the fact that most of the employers come to UNB to hire our students to work as Land Surveyors in western Canada, where the economy is currently flourishing and demand is very high.

4. MAKING THE CHANGES

The collegial process of making changes at UNB (and probably at most universities) tends to make the process of introducing change extremely slow, but we have made a start.

4.1 Process

We have already discussed the report of the consultants at our annual GGE Department strategic planning session, and subsequently at department meetings. At the previous year's strategic planning session, we developed the first draft of a 160 credit hour degree – this was subsequently finalized at the department level after further discussion. Once approved at the department level, proposed curriculum changes then have to obtain approval from the Faculty of Engineering Curriculum Committee, the whole Faculty of Engineering, then finally the Senate curriculum committee. This long process helps both: (1) ensure the opportunity for sufficient feedback and discussion on proposals; and (2) enable faculty members to feel engaged in the decision making process –crucial to the success of change.

4.2 Results

New 4-year degree: We have developed a 160 credit hour (ch) degree which we believe can be completed in 4 years by the average student. The number of credit hours per term does fluctuate, but is never too far from the average of 20 ch per term. This is a major achievement, having reduced the degree length by 20 credit hours from its 180 ch length in 2005 (requiring many students to spend 5-5.5 years at UNB). It does, however, place an additional onus on the faculty members because an even higher proportion of the courses are taught within the Department at a time when replacement of faculty after retirements has become a greater issue on campus. A breakdown of the new undergraduate GGE core program with the Cadastral Survey Option is illustrated in Figure 5.

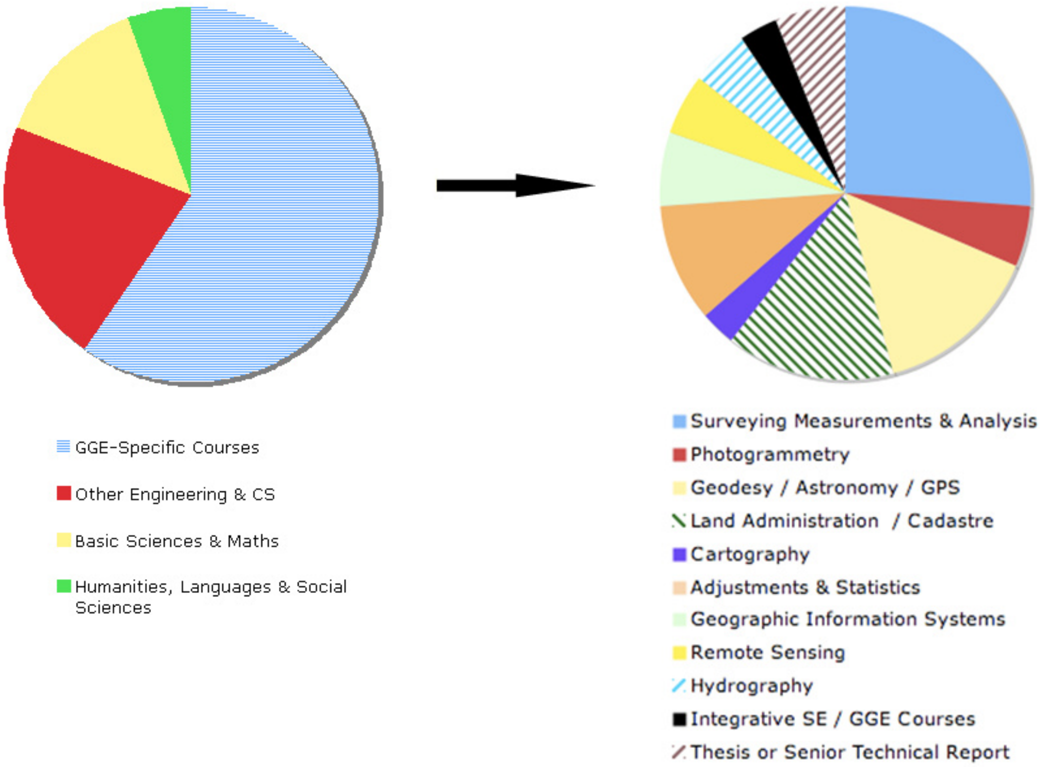


Fig. 5: 2007 Geomatics Engineering Curriculum w/ Cadastral Survey Option

Business skills: We already have at UNB courses in business skills, and there are probably two reasons why students were not following these courses: (1) the courses would be additional to the 180 ch degree, thus further increasing the length of stay at UNB, and student debt, and (2) they were unaware of the courses. Rather than integrate any additional courses into the core program itself, we held a special information lunchtime lecture for students so that they are aware of the Faculty of Engineering diploma in Technology Management and Entrepreneurship, and the minor in Business offered by the Faculty of Business Administration.

New Technology: We are creating a new team-taught elective course encompassing terrestrial laser scanners, LiDAR, GNSS, multibeam, and 3D visualization. We intend to emphasize the similarity of the measurement techniques so that when new measurement techniques are developed in the future, the students will be able to identify the principles of the measurement system and so be able to plan for certain error sources and limitations.

5. TOWARDS THE FUTURE

As we continue to move forward with our new 4-year 160 ch degree, we continue to rethink what we should be offering considering enrollment requirements at UNB, and providing an excellent service to our students.

The Department is at the very early stages of considering offering a new 3-year non-engineering degree program in addition to our existing program. This degree, to be accredited by CCLS and maybe RICS, would be designed serve those students wishing to pursue a career in Land Surveying but not professional engineering. As mentioned earlier in the paper, many students transfer into the diploma program from community colleges, and having a shorter degree still recognized by CCLS may tempt those students to come to GGE directly from high school. Assumptions are still being tested and internal discussions are currently underway.

We intend to make efforts to change the perception of what our students can do when they graduate. Through a combination of an e-newsletter to companies, alumnae and schools, and announcements in the Canadian Institute of Geomatics publication 'Geomatica', we hope to inform these groups on the type of engineering work our students can do in addition to land surveying. We hope that this will encourage more employers outside of land surveying to look to GGE for their future employees, and – through schools – let future students know what opportunities exist after completing the undergraduate degree.

As we look to the future, it is worth mentioning here that we plan to increase our attention on our M.Eng. degree. Offered as a graduate degree completed through graduate courses only, we plan to restructure this degree to possibly offer courses over a one month duration, with the degree being completed over 12 months. In addition to offering this in Fredericton, we are at the early stages of investigating the feasibility of offering this from an overseas UNB campus.

There are some interesting times ahead!

REFERENCES

Blachut, T.J. [1957]. "Is Special Education in 'Surveying' Necessary?" *The Canadian Surveyor*, Vol. XIII, No. 7.

CCLS [2007]. Canadian Council of Land Surveyors. Information obtained from the Canadian Council of Council of Land Surveyors Web site at *http://www.ccls-ccag.ca/files/Acred%20Policy.pdf* (Last accessed 27 March 2007)

CEAB [2007]. Canadian Engineering Accreditation Board. Information obtained from the Canadian Council of Professional Engineers Web site at *http://www.ccpe.ca/e/ccpe_boards_2.cfm* . (Last accessed 27 March 2007)

Dobbin, James [1999]. "Regulation of the Land Surveying Profession in Canada". Unpublished Master of Engineering Report, Department of Geodesy and Geomatics Engineering, University of New Brunswick, Canada.

Gourman Report [1999]. *The Gourman Report - Undergraduate Programs*, 10th Edition, 1999 Random House, Inc. ISBN 0-679-77780-6

Love, R.J. [1975]. "Proposals for Training and Qualifications of Land Surveyors, Survey Technicians and Technologists in Atlantic Canada. Unpublished report to the Council of Maritime Premiers Secretariat, Halifax, Nova Scotia, Canada.

BIOGRAPHICAL NOTES

Dr. David Coleman, P.Eng., FCAE has been a faculty member of the Department of Geodesy and Geomatics Engineering at the University of New Brunswick since 1993. Prior to joining UNB, he spent 15 years in the Canadian geomatics industry as a project surveyor, engineer, executive manager and consultant. He has authored over 150 publications and reports dealing with land information policy development, geomatics operations management, geographic information standards and spatial data infrastructure. He is a Fellow of the Canadian Academy of Engineering, a Past-President of the Canadian Institute of Geomatics, and a member of Advisory Boards to Natural Resources Canada and the Department of National Defence. Since 1990, he has acted as a consultant on projects in Canada, Australia, the United Kingdom and South America.

Dr. Peter Dare, FRICS, joined the Department of Geodesy and Geomatics Engineering at UNB in August 2000. Before joining UNB he worked in the School of Surveying, University of East London, England. His main areas of expertise are in Geodesy, GPS and Operational Research but in addition he has experience in the broad field of Geomatics. Peter has been involved in a number of international projects including GPS work in Turkmenistan, Mauritius, Seychelles and Malta. With his research team Peter carries out research on GPS, with a special focus on the Arctic and studying the atmosphere with GPS. Some of the data collected from his work is provided to the U.S. National Weather Service to improve its weather forecasts. The data is also shared with the Canadian Meteorological Service, which has recently begun testing the use of GPS-derived data in its weather forecasts. Peter is a member of the Institute of Navigation, the Canadian Institute of Geomatics, the American Geophysical Union, and the Canadian Geophysical Union. He is also a Fellow of the Royal Institution of Chartered Surveyors. Peter is active on committees of the Royal Institution of Chartered Surveyors, International Federation of Surveyors, International Earth Rotation Service, and the International Association of Geodesy. In 2002, Peter became the Chair of the Department of Geodesy and Geomatics Engineering.

CONTACTS

Dr. David J. Coleman, Professor & Dean of Engineering
Department of Geodesy and Geomatics Engineering
University of New Brunswick, P.O. Box 4400
Fredericton, New Brunswick E3B 5A3
CANADA
Tel. +1-506-453-4570
Fax. +1-506-453-4569
Email: dcoleman@unb.ca
Web Site: *http://gge.unb.ca/Personnel/Coleman/Coleman.html*

Dr. Peter Dare, Professor & Chair of Department
Department of Geodesy and Geomatics Engineering
University of New Brunswick, P.O. Box 4400
Fredericton, New Brunswick E3B 5A3
CANADA
Tel. +1-506-453-4698
Fax +1-506-453-4943
Email: dare@unb.ca
Web site: http://gge.unb.ca/Personnel/Dare/Dare.html

Promoting the Interaction between Education, Research and Professional Practice

Stig ENEMARK, Denmark

Key words: surveying education; curriculum development; professional competence.

SUMMARY

Curriculum development is the key to the future. It is an ongoing process and it is crucial to both the educational institutions and the society they serve. This relates especially to educational programs designed to professionals such as the surveyors.

There is no doubt that the main challenge of the future will be that the only constant is change. To deal with this constant change the educational base must be flexible. The graduates must be adaptable to a rapidly changing labour market. The point is that professional and technical skills can be acquired and updated at a later stage in ones career while skills for theoretical problem-solving and skills for learning to learn can only be achieved through the process of academic training at the universities. The focus should be on educating for life - not for short term skills.

The paper touches on a range of issues and lessons learnt with a special emphasis on ways and means of building professional competence through curriculum development. The basic argument is that development, maintenance and enhancement of professional competence should be seen as a process facilitated through an efficient interaction between education, research and professional practice.

1. INTRODUCTION

Let me start by presenting some key international trends in surveying education. These are presented previously (Enemark and Prendergast, 2001) but they are still very valid and actual. In a short version, the trends are as follows:

Management skills, versus specialist skills. Technological developments take the skill out of measurement and the processing of data. Almost any individual can press buttons to create survey information and process this information in automated systems. In the same way, technological developments make GIS a tool available to almost any individual. The skill of the future lies in the interpretation of the data and in their management in such a way as to meet the needs of customers, institutions and communities. Therefore, *management skills will be a key demand in the future surveying world.*

Project organised education, versus subject based education. An alternative to traditional subject-based education is found in the project organised model where traditional taught courses assisted by actual practice are replaced by project work assisted by courses. *The aim* *is broad understanding of interrelationships and the ability to deal with new and unknown problems.* In general, the focus of university education should be more on "**learning to learn**". The traditional focus on acquisition of professional and technical skills (knowing how) often imply an "add-on" approach where for each new innovation one or more courses must be added to the curriculum to address a new technique. It is argued that this traditional subject-based approach should be modified by giving increased attention to entrepreneurial and managerial skills and to the process of problem-solving on a scientific basis (knowing why).

Virtual academy, versus classroom lecture courses. There is no doubt that traditional classroom lecturing will be supported by or even replaced by virtual media. This trend will challenge the traditional role of the universities. *The traditional focus on the on-campus activities will change into a more open role of serving the profession and the society.* The computer cannot replace the teacher and the learning process cannot be automated. However, there is no doubt that the concept of virtual academy represents new opportunities especially for facilitating for process of learning and understanding and for widening the role the universities. And the www techniques for course delivery on a distant learning basis represent a key engine especially in the area of lifelong learning programmes.

Lifelong learning, versus vocational training. There was a time, when one qualified for life, once and for all. Today we must qualify constantly just to keep up. It is estimated that the knowledge gained in a vocational degree course has an average useful life span of about four years. The concept of lifelong learning or continuing professional development (CPD) with its emphasis on reviewing personal capabilities and developing a structured action plan to develop existing and new skills is becoming of increasing importance. In this regard, *university graduation should be seen as only the first step in a lifelong educational process*.

2. GLOBAL DRIVERS FOR CHANGE

The trends presented above all relate to the change deriving from the global drivers for change in the spatial information world. These can be identified as technology development, micro-economic reform, globalisation, and sustainable development (adapted from Williamson and Ting, 1999). These global drivers therefore also affect the profile of the surveying profession and they challenge the whole educational basis of the profession. The global drivers are as follows:

Technology development is the major driving force in changing the face of the spatial information world. The GPS technologies for measuring have revolutionised the traditional surveying discipline and the high resolution satellite imagery tends to revolutionise the mapping discipline. The database technologies for storage of large data sets and the GIS technologies for data management, analysis and manipulation arguably have had the greatest impact on the spatial information environment. And in the future the communication technologies such as the WWW and the Internet will become the focus of attention for viewing and using spatial data. However, it must be acknowledged that technological development is not the only driver.

Micro-economic reform in many countries has had a dramatic impact on the spatial information environment. The micro-economic reform initiatives represent the institutional and governmental side of the changes observed during the latest two decades. This includes initiatives such as privatisation, decentralisation, downsizing, cost recovery, performance contracts, quality assurance, public/private partnership, and other policies to ensure service delivery and cost effectiveness. These initiatives have changed the focus from the pure technological issues to include also the more managerial components of building and maintaining national spatial data infrastructures.

Globalisation is becoming a reality driven by IT and communication technologies. A globalised world is one in which political, economic, cultural, and social events become more interconnected. The process includes that events in one part of the world increasingly have potential to impact on people and societies in other parts of the world. Globalisation widens the perspectives from the local to the global level. This should lead to a world movement towards improving the quality of lives of people by thinking, working together on common concerns. Globalisation has a social, economic, political, as well as an educational dimension. The www - and mash-ups such Google Earth – are the most graphic example of this trend, even if the full potential of the web as an educational resource is still to be seen.

Sustainable development will be a driving force in policies developed through the decades ahead. Sustainable development means development that effectively incorporates economic, social and environmental concerns in decision making for development which thereby should "meet the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission, 1987). The professional areas of land administration and, more generally, land management include decision making of such a multidisciplinary nature to be carried out at national, regional and local level of government.

Taking these global drivers into account, it is no surprise that changes are taking place in the definition and nature of the surveying education, as well as the surveying profession and professional practice. Changes in technology and institutional frameworks may provide new opportunities for the surveying profession, but they will also be the destroyers of some professional work. The challenges will be to integrate modern surveying technology into a broader process of problem solving and decision making.

This leads into the understanding that surveying education can no longer rely on measurements skills in relation to engineering and cadastral surveys. There is a need for changing the focus from an engineering discipline into a more managerial and interdisciplinary perspective. The strength of our profession lies in its multidisciplinary approach supported by skills for mediation and project management. The strength lies in the combination of technical, legal, and managerial competence when dealing with development opportunities and property rights and restrictions.

Curriculum development in Surveying (or Geomatics) should therefore be designed in a fruitful cooperation between the responsible faculty board, the faculty research staff; and the professional stakeholders in terms of the professional surveying institution and relevant employers of the graduates. This interaction should ensure that curriculum development is carried out in response to professional and societal needs.

3. EDUCATION, RESEARCH AND PROFESSIONAL PROCTICE

A successful educational system depends on a comprehensive interaction between education, research and professional practice. This dynamic interaction is shown in figure 1 below (Kjaersdam and Enemark, 1994).

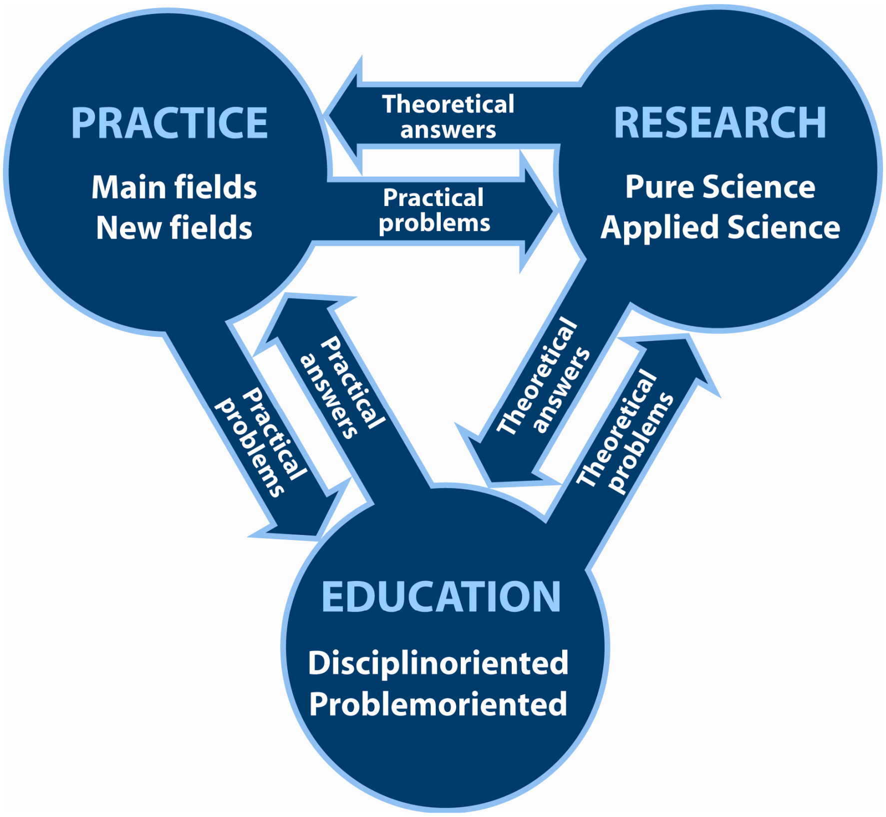


Fig. 1: The interaction between education, research and professional practice

Practice can be defined as specific fields or tasks within society that conform professional functions which are carried out by professional academics such as surveyors or civil engineers. In a society of increased complexity the professionals continually face new problems and new challenges in practice. The traditional way to deal with these challenges is through in-service training, professional seminars, publication of articles, etc. However, this method of development is a rather slow process. The answers, or even the problems themselves, may no longer be of current relevance when the solutions are found. And, at the same time, society is still developing new problems which require new solutions.

Therefore, in order to make improvement research and education should be involved in the development process in order to establish a dynamic interaction as shown in fig.1. Research is needed to produce theoretical answers, and interplay with education is needed to produce graduates who are capable of producing practical answers by applying new knowledge and skills when dealing with the new and unknown problems of the future.

3.1 Problem solving and applied science

Applied science is used mainly to deal with problems that can be observed in the "real world". Applied science is problem-oriented by nature. The scientific process of such problem-oriented research can be described as shown in figure 2.

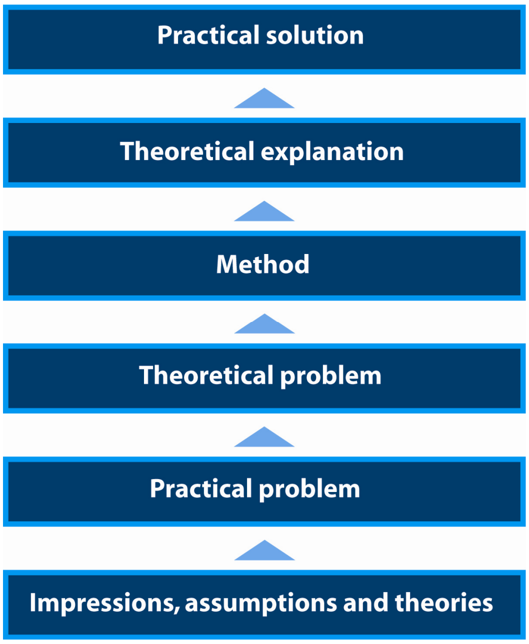


Fig. 2: A model for problem-oriented research.

As a basis for attaining a conscious perception we have a number of impressions, assumptions, and theories built into our language, culture, professional practice and way of life. It is those impressions, assumptions, and theories that guide us in our professional lives. But sometimes we face situations where they are inadequate or insufficient and then practical problems arise.

The practical problem can be a symptom that something is wrong with our theories and assumptions. As a consequence, the practical problem produces a theoretical problem as to why there is a practical problem. The solution to a theoretical problem is a new theory that explains the problem. If the theoretical explanation of the causes of the practical problem can provide a solution to it, there is strong evidence that the theory is valid. What is described here is the dynamic interplay between practice and research, where practice produces practical problems (inter alia) and research produces theoretical possibilities and answers by producing new knowledge.

Applied science is in principle restricted to deal with the problems that are recognized in practice and identified outside the scientific world. Applied science then has the freedom to apply any theory or method that may be relevant for solving the problem. In contrast, pure Science is normally limited by specific paradigm in terms of choice of theory and methods to be used. This dialectic interplay between Applied and Pure Science provides for scientific progress.

This scientific interplay produces new paradigms, new theoretical explanations, and new practical solutions. But it often takes many years to achieve these innovations. Therefore, to produce graduates with relevant qualifications to deal with the problems of the future the faculty must be composed by active researchers. This also indicates the need for integration between education and research and professional practice. To pursue this aim, it is essential to design curricula which are flexible and easily adaptable. Then, the curricula will be able to deal with the most actual professional problems and their current implications in society.

3.2 Educational innovation

Traditional higher education has been focused on rule-based disciplines with independent identities in their own contexts. In the discipline-oriented education, the special disciplines and theories, which are considered necessary/relevant for the specific subjects, are normally taught by means of set textbooks and lectures. The students become experienced in the use of these disciplines and theories through the exercises and case work that support these theories. The aim is specific knowledge in certain fields and standard solutions to standard problems. This system functions quite well in a stable society where the individual functions and tasks are reasonably standardized.

In contrast, problem-oriented education is based on working with relevant, current and unsolved problems from society/industry/real life. By analysing the problems in depth the students learn and use the disciplines and theories which are considered necessary and relevant to solve the problems posed, i.e. the problems defines the subjects and not the reverse. Organizing problem-oriented education through project work allows groups of students to choose problems and to try to analyze and solve them. Through the project work the students should acquire the necessary basic knowledge by means of literature and lecture courses and, at the same time, develop the ability to formulate, analyze and solve relevant problems. In principle, it can thus be ensured that the graduates are capable of handling also the unknown problems of the future.

Educational innovation can then be achieved by being aware of the necessary dialectics between discipline and problem oriented education. The disciplines and their related theories are necessary for the graduates´ fundamental academic and professional basis. On the other hand, the problem oriented project work is necessary in order to understand the interdisciplinary character of the problems in industry/society/real life, and to enable the graduates to deal with the new and unknown problems of the future. The aim is broad insight into and understanding of the connections between different fields and skills in order to be able to function in an ever-changing and increasingly more complicated society (Enemark, 2002).

4. LEARNING TO LEARN

One of the main challenges of the future will be to accept that the only constant is change. To deal with this constant change the educational base must be flexible. Graduates must possess skills to adapt to a rapidly changing labour market and they must possess skills to deal even with the unknown problems of the future. Professional and technical skills can be acquired and updated at a later stage in one's career while skills for theoretical problem-solving and skills for "learning to learn" can only be achieved through academic training at the universities.

A number of research studies (e.g. Coleman, 1998) have confirmed that students retain only 10 per cent of what they read and only 20 per cent of what they hear. However, if a problem is simulated, then up to 90 per cent of the lessons learned may be retained. This finding is behind the shift in the pedagogical doctrine toward project work and problem-based learning. It emphasizes learning instead of teaching. Learning is not like pouring water into a glass. Learning is an active process of investigation and creation based on the learners` interest, curiosity and experience and should result in expanded insights, knowledge and skills (Kolmos, 1996).

A consequence of this shift from teaching to learning is that *the task of the teacher is altered from the transferring of knowledge into facilitating learning.* Project work also fulfils an important pedagogical objective. Student must be able to explain the results of their studies and investigations to other students in the group. This skill appears to be vital to professional and theoretical cognition: *Knowledge is only established for real when one is able to explain this knowledge to others.* In traditional education the students restore knowledge presented by the teacher. When the project organized model is used, the knowledge is established through investigations and through discussion between the student members of the project group, and mainly without the presence of the teacher.

5. PROJECT-ORGANIZED AND PROBLEM BASED LEARNING

The PBL approach applied at Aalborg University is both project-organised and problem- based. In order to provide for the use of project work as the basic educational methodology the curriculum has to be organised into general subjects or "themes" normally covering a semester. The themes chosen in a programme must be generalised in such a way, that the themes in total will constitute the general aim or professional profile of the curriculum. The themes must provide for studying the core elements of the subjects included (through the lecture courses given) as well as exploring (through the project work) the application of the subjects in professional practice. The principles of project-organised and problem-based learning are shown in figure 2 below (Kjaersdam and Enemark, 1994).

Real life problems are not defined in surveying/engineering terms. Therefore Problems analysis and formulation of the problem in surveying/engineering terms is important before staring the problem solving problems. Through this process the students also develop skills for communications and documentation of the results – as is the case in real life.

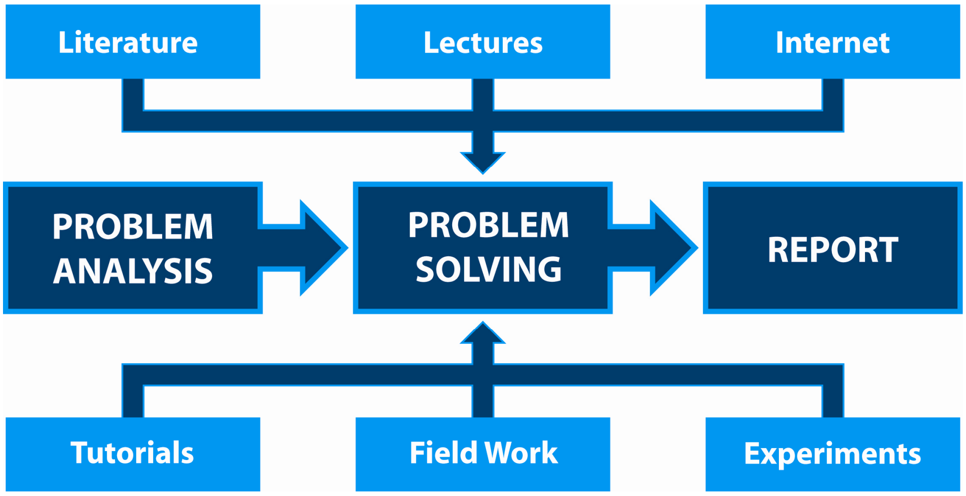


Fig. 3: Principles of project-organised and problem-based learning

Project-organized means that traditional taught courses and labs is replaced by project work assisted by lecture courses. The project-organized concept moves the perspective from description and analyzing into synthesizing and assessment. The concept is based on a dialectic interaction between the subjects taught in the lecture courses and the problems dealt with in the project work. Each term has a basic structure containing, in principle, equal distribution of lecture courses and project work. But the study-time is dominated by lecture courses at the beginning of the term and by project work at the end. The project work is carried out by groups of four to six students having a teacher appointed as their supervisor.

Problem-based means that traditional textbook-knowledge is replaced by the knowledge necessary to solve theoretical problems. The problem-based concept moves the perspective from understanding of common knowledge into ability to develop new knowledge. The aim of the project work is "learning by doing" or "action learning". The project work may be organized by using a "know-how" approach for training professional functions, or it may be organized by using a "know-why" approach for training methodological skills of problem-analysis and application. The former is normally applied in first half of the curriculum where the necessary disciplines are taught in the lecture courses. The latter is applied in the second half of the curriculum and is supported by lecture courses presenting the necessary theories within the specific professional areas.

The difference between traditional subject-oriented education and this project-oriented educational model may be expressed in short by an old Chinese proverb:

"Tell me and I will forget
Show me and I will remember
Involve me and I will understand
Step back and I will act"

5.1 Curriculum design

In order to provide for the use of project work as a basic educational element the curriculum has to be organised into general subjects or "themes" normally covering a semester. The themes chosen in a programme must be generalised in such a way, that the themes in total will constitute the general aim or professional profile of the curriculum. The themes should provide for studying the core elements of the subjects included (through the lecture courses given) as well as exploring (through the project work) the application of the subjects in professional practice. The curriculum for educating chartered surveyors in Denmark (Fig 4.) may be used as an example to illustrate the selection of themes as well as to explain the adaptability of the educational model.

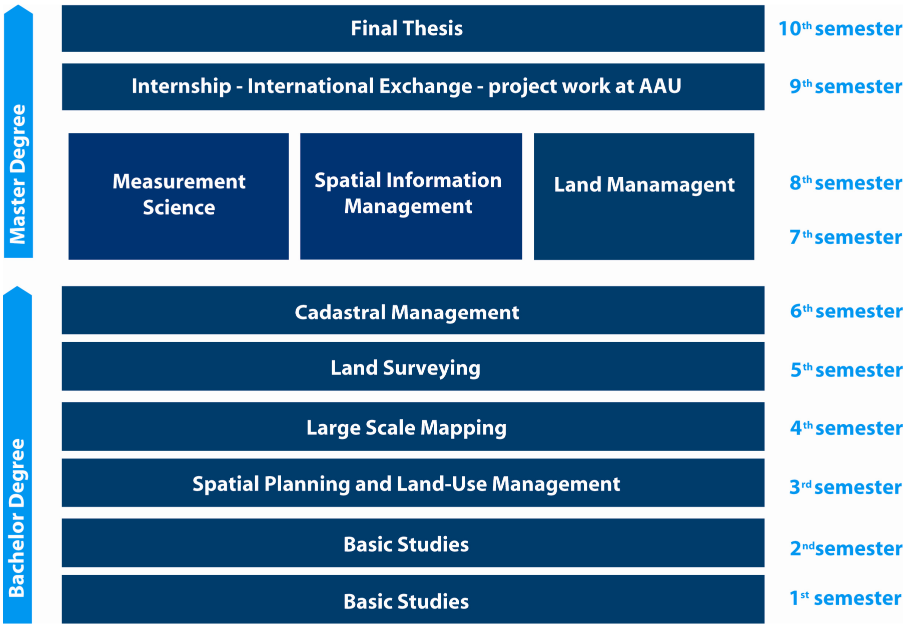


Fig. 4: The curriculum for educating chartered surveyors at Aalborg University, Denmark

Each semester has a basic structure containing, in principle, an equal distribution of lecture courses and project-work. But the study-time is dominated by courses at the beginning of the semester and term and by project-work at the end.

There are two types of lecture courses: curriculum related courses and project related courses. The aim of the curriculum related courses is to establish the necessary fundamental and general scientific knowledge in relation to the curriculum. The aim of the project related courses is to deal with the theoretical and professional contents of the theme. The professional and discipline oriented approach dominate the lecture courses given in the undergraduate studies, while the theoretical and scientific approach dominate lecture courses given at the graduate level. In the entire curriculum 50% of the study time is spend on project, 25% on lecture courses related to the project work, and 25% on lecture curses related to the curriculum.

The aim of the project-work is "learning by doing" or "action learning". The professional skills are established during the discipline-based project-work, which is dominating at 3-6 semester.

The professional cognition and the methodical skills are established during the problem-based project-work at 7-10 semesters where the ability of carrying out independent investigations on a scientific interdisciplinary basis is trained. Also the ability of presenting independent conclusions and the ability of finishing the project in time is trained. In fact the process of the project-work at this stage is very similar to the problem-solving process in practice.

6. THE ONLY CONSTANT IS CHANGE – CASE STUDY DENMARK

The professional profile of the Danish surveyor is a combination of technical, judicial and design areas. The profile thus is a mix of an engineer, a layer and an architect. The professional fields then consist of three areas: surveying and mapping, land administration (including cadastral management), and land management (including spatial planning). Cadastral tasks are the monopoly of licensed surveyors in private practice, and the role of this private surveyor has traditionally epitomised the Danish surveyor. However, both the structure of the surveying profession and the profile of the Danish surveyor are turned upside down through the latest two or three decades.

Since the late 1960´s the Danish Association of Chartered Surveyors has carried out a survey of the surveying profession every 10 years starting in 1967. The changes taken place over these 30 years and especially over the latest two decades are quite remarkable. The evolution of surveying profession in Denmark is shown in the figure 5 below.

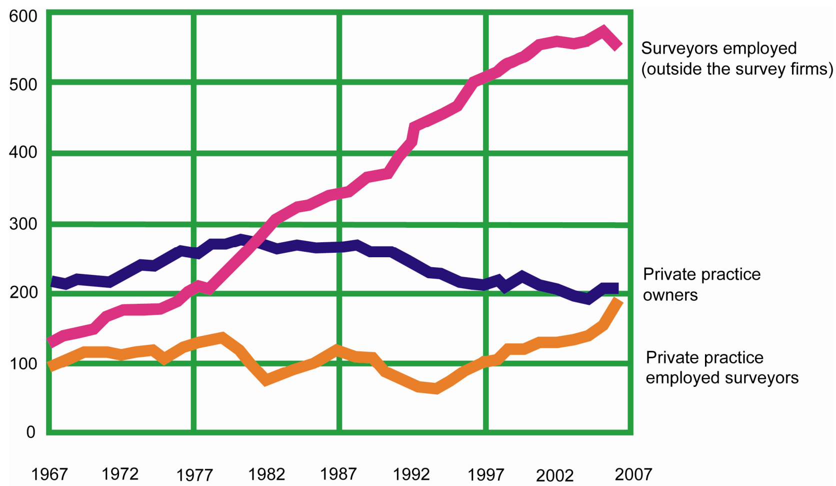


Fig. 5: The evolution of surveying profession in Denmark

In 1967 the number of surveyors working in the private surveying firms accounted for about two thirds of the total profession while surveyors employed in the public sector or in other private business accounted for only one third. In 1997 the situation is reversed. Two thirds of the profession is employed outside the private surveying firms. During these 30 years the number of active surveyors is doubled from about 450 in 1967 to about 850 in 1997. This means that the growth is located within the surveyors employed in the public sector or other private business while the number of surveyors working in the private surveying firms has been more or less steady over during the last 40 years (Enemark, 2003).

Over the same period, the general professional profile has changed completely. In 1967 and still in 1977 the profile of the Danish surveyor was dominated by the cadastral area while in 1997 it accounts for only 20 percent of the total working hours. In 1997 the distribution was as follows: Planning and Land Management 23 %, Cadastral Work 20 %, Mapping and Engineering Surveys 26 %, and "Other Areas" 31%. Next to the decrease in the cadastral area it is remarkable that the biggest area in 1997 is located outside the traditional working areas. These "other task areas" include general management, general IT-development, and other business developments. The evolution of the professional profile in Denmark is shown in the diagram below. It will be interesting to see the results of the next survey being carried out in 2007 (Enemark, 2003).

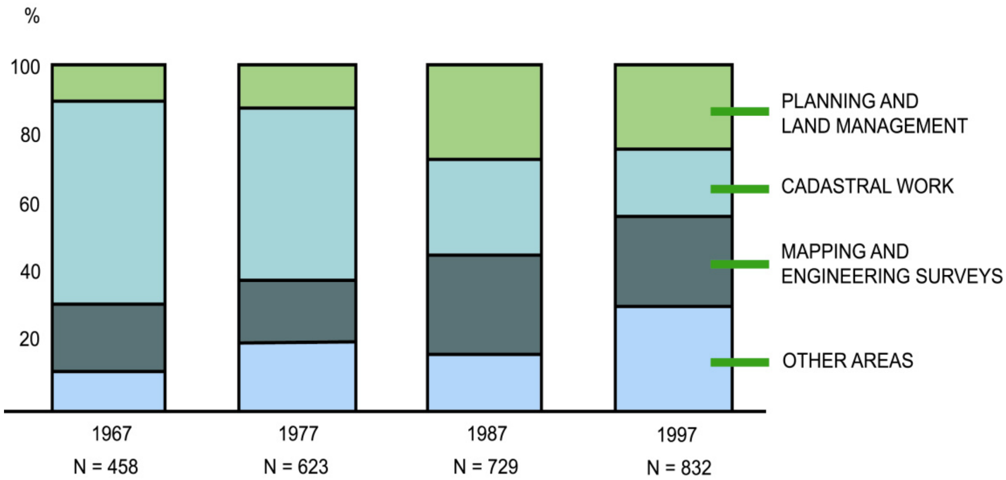


Fig. 6: The evolution the professional profile of the Danish Surveyor

The changes shown above are significant and must of course be reflected in content and structure of the educational base. In fact, the changes have been coped with rather easily within the profession and also with regard to the labour market. It is safe to assume that this is mainly due to the flexible and easily adaptable educational model that was introduced in 1974 when the surveying programme was moved from the Royal Veterinary and Agricultural Academy in Copenhagen to a new university established in Aalborg.

7. THE EDUCATIONAL CHALLENGE

The developments as discussed above have a significant educational impact. There is a need to change the focus from being seen very much as an engineering discipline. There is a need for a more managerial and interdisciplinary focus. The strength of our profession lies in its multidisciplinary approach.

Surveying and mapping are clearly technical disciplines (within natural and technical science) while cadastre, land management and spatial planning are judicial or managerial disciplines (within social science). The identity of the surveying profession and its educational base therefore should be in the management of spatial data, with links to the technical as well as social sciences.

The universities should act as the main facilitator within the process of forming and promoting the future identity of the surveying profession. Here, the area GIS and, especially, the area managing geographical and spatial information should be the core component of the identity. This responsibility or duty of the universities, then, should be carried out in close co-operation with the industry and the professional institutions.

The challenge of the future will to implement the new IT-paradigm and this new multidisciplinary approach into the traditional educational programmes in surveying and engineering. A future educational profile in this area should be composed by the areas of Measurement Science and Land Administration and supported by and embedding in a broad multidisciplinary paradigm of Spatial Information Management. Such a profile was promoted at the FIG/CLGE seminar on Enhancing Professional Competence of the Surveyor in Europe, held in Delft, November 2000, and increasingly it seems to become generally accepted world wide. The profile is illustrated in figure 7 below (Enemark and Prendergast, 2001).

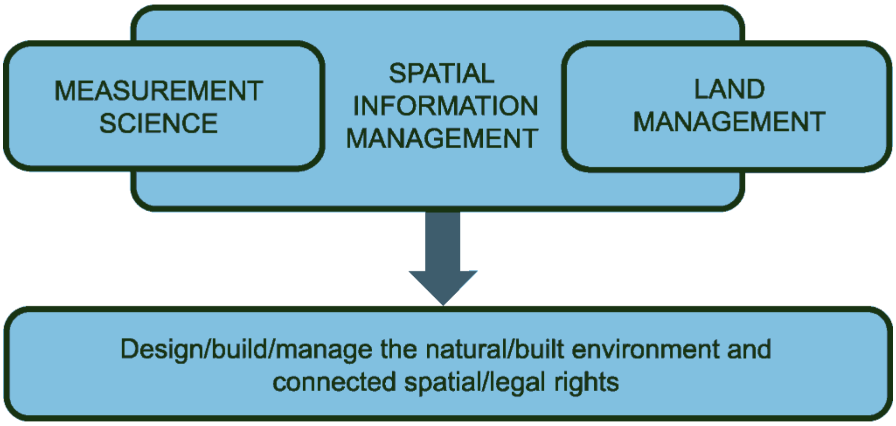


Fig. 7: The educational profile of the future

Both in Europe and in US there are examples of surveying programs being closed down due to the fact that they have insisted on maintaining the traditional technical focus and have not changed to comply with a more interdisciplinary approach. On the opposite, programs that have changed to comply with a broader and more interdisciplinary approach seem to flourish.

The affiliation with engineering science has served the surveying discipline well. However, the future will possibly rather point at an alliance with Geography based on Spatial Information Management and focusing on Land Management. There will still be a need for teaching the basic skills within measurement and mapping, and it should still be possible to specialize within these areas. We must, however, be aware that the GPS technology makes these disciplines available also for many other professions and for non-professionals as well.

8. THE MANAGERIAL CHALLENGE

The managerial challenge relates to a range of issues that will all have an impact on running the programmes. Three key areas can be identified in terms management challenges:

Structural changes. These may relate to changes in departmental structures that may impact the educational profile; available resources are always a key factor and these may not be stable; and the student base may vary a lot over the years. At national level changes may occur in relation to governmental responsibilities, performance criteria, and resources allocated to the universities. International agreements, such as the Bologna Agreement within the European Union, may also causes a whole range of structural changes that impact both the educational profile and the way it should be managed. Structural changes often jeopardise educational programmes and call for leadership focusing on visions, processes, and outcome in terms of professional competence of the graduates.

Quality assurance. The capability and the quality of the programmes should be assessed continually within the educational system itself. Such a system of internal monitoring serves the purpose of quality management with regard to the relevance and quality of the lecture courses as well as the quality of the entire semester concerning supervising, organisation and resources. Ideally the system of quality management should be built into the educational model, and the processes should be described in a “Handbook of Quality Control”. These processes should be carefully designed to underline the common responsibility for improving the quality of programmes as well as the quality of the total study environment. The development and implementation of such a system is basically about creating a quality culture (Enemark, 2000). The students play a very key role in the process. The students at each semester should understand that only by fulfilling the duty of a serious evaluation of the past semester they can enjoy the benefits of commencing an improved up-coming semester themselves. Procedures for quality assurance are a must and, ideally, they should form an ongoing circle of quality improvement (see FIG publication no. 19, 1999)

Accreditation, monitoring and assessment. Procedures for accreditation vary a lot throughout the world and also within regions of the world. Basically accreditation is about evaluating whether a certain program meets some minimum standard criteria. Such systems of accreditation tend to become the norm at national as well as international level. Design of an adequate system of quality assurance is important in this regard. It is also important to establish adequate systems of monitoring the labour market both in terms of employment of the graduates and in terms of the whether the competences of the graduates meet the demands of the various employment areas. Such documentation is increasingly important as a tool of justification but also as a tool for strategic management and curriculum development. Assessment of such monitoring should be carried out in cooperation with representatives from the employment areas e.g. by establishing an “Advisory Board” with representatives from the key employment areas, representatives from the faculty staff, the students, as well the professional association. Such a forum may also discuss the balance between the different areas in the program, and thereby identify any needs for adjustments in relation to the demands of the various employment areas. The forum may also discuss the interaction between the university program and various activities of continuing professional development.

9. THE PROFESSIONAL CHALLENGE

The term professional competence relates to a status as an expert. This status cannot be achieved only through university graduation and it cannot be achieved solely through

professional practice. University graduation is no longer a ticket for a lifelong professional carrier. Today one must qualify constantly just to keep up. The idea of "learning for life" is replaced by the concept of lifelong learning. No longer can "keeping up to date" be optional, it is increasingly central to organisational and professional success.
The response of the surveying profession, and many other professions, to this challenge has been to promote the concept of continuing professional development (CPD) as a code of practice to be followed by the individual professionals on a mandatory or voluntary basis. Maintaining and developing professional competence is of course the responsibility of the individual practitioner. This duty should be executed by adopting a personal strategy which must be followed systematically. Implementation of such a plan, however, relies on a variety of training options to be offered by different course providers, including the universities (see FIG publication no. 16, 1996).

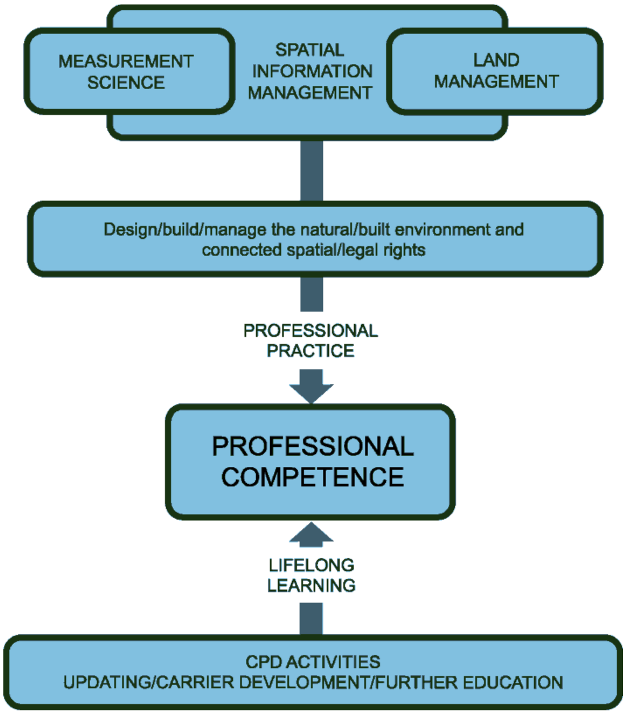


Fig. 8: The professional competence model

The individual practitioner should be able to rely on a comprehensive CPD concept which is generally acknowledged by the profession and which is economically supported by the industry (public as well as private). Furthermore, the practitioner should have a variety of training and development options available for implementation of his or her personal plan of action. The options should be developed by the universities offering for example one-year masters courses as part time studies based on distance learning; and also by private course providers offering short courses for updating and just-in-time training. These options should be developed in co-operation between the universities, the industry and the professional associations.

Furthermore, the individual practitioner should be able to rely on a comprehensive concept for getting his or her professional competence recognised in a regional and global context. There is an attraction in developing and extending such a principle of Mutual Recognition of Professional Qualifications. Mutual recognition allows each country to retain its own kind of professional education and training because it is based, not on the process of achieving professional qualifications, but on the nature and quality of the outcome of that process. In turn this should lead to enhancement of the global professional competence of the surveying profession. And the national associations as well as the universities should play a key role in facilitating this process (see FIG publication no. 27, 2002).

In short, enhancement of professional competence relies on an efficient interaction between education, research and professional practice. To facilitate this interaction – based on mutual respect - is the true challenge of the new millennium.

10. FINAL REMARKS

Even if the content of surveying curricula may vary between countries, some general trends can be identified. There is clearly a trend towards increased focus on managerial issues and the acquisition and application of interdisciplinary problem-solving skills. Regarding course delivery, there is a trend towards increased use of project-based education as well as skills for teamwork, co-operation and communication. And web based learning tends to become an integrated tool for course delivery.

The challenge of the future will be to apply the new IT-paradigm and a new interdisciplinary approach to surveying education. Furthermore, it should be recognised that the only constant in the future is change. To deal with such significant change the educational base must be flexible. The graduates must process skills to adapt to a rapidly changing labour market and they must process skills to deal even with the unknown problems of the future. Therefore, skills for learning to learn have become increasingly essential.

The paper identifies three major challenges in terms of curriculum development. These relates to the educational profile, the managerial qualifications, and the professional competence of the graduates. Each of these challenges is analyzed in some length.

The paper states that curriculum innovation essentially depends on establishing an efficient interaction between education, research and professional practice as the key driver.

REFERENCES

Coleman, D.J. (1998): Applied and Academic Geomatics into the Twenty-First Century. Proceedings of FIG Commission 2, the XXI International FIG Congress, Brighton, UK.

Enemark, S. (2000): Creating a Quality Culture. In: Towards Best Practice – Quality Improvement Initiatives in Higher Education Institutions, Nordic Council of Ministers (ed.), Tema Nord, No 2000:501, pp 53-63.

Enemark, S.: (2002): Innovation in Surveying Education. Global Journal of Engineering Education, Volume 6, Number 2, Melbourne, pp 153-159. ISSN 1328-3154.

Enemark, S. (2003): Surveying the Surveying Profession. Survey Review, Vol. 37, No 288, April 2003, pp 137-144. ISSN 0039-6265.
Enemark, S. and Prendergast, P. (Eds.), (2001): Enhancing Professional Competence of Surveyors in Europe. FIG and CLGE, FIG Office Copenhagen.
FIG (1996): Continuing Professional Development and its future Promotion within FIG. FIG publications no 16, 28 p.
FIG (1999): Quality Assurance in Surveying Education. FIG publication series no 19, 40 p.
FIG (2002): Mutual Recognition of Professional Qualifications. FIG publication no 27, 28 p.
Kjaersdam, F. and Enemark, S. (1994): The Aalborg Experiment - Project Innovation in University Education. Aalborg University Press.
Kolmos, A. (1996): Reflections on Project Work and Problem Based Learning. In: European Journal of Engineering Education, Vol. 21, No 2, pp 141- 148.

BIOGRAPHICAL NOTES

Stig Enemark is President of the International Federation of Surveyors, FIG. He is Professor in Land Management and Problem Based Learning at Aalborg University, Denmark, where he was Head of the School of Surveying and Planning 1991-2005. He is Master of Science in Surveying, Planning and Land Management and he obtained his license for cadastral surveying in 1970. He worked for ten years as a consultant surveyor in private practice. He was President of the Danish Association of Chartered Surveyors 2003-2006. He was Chairman of Commission 2 (Professional Education) of the International Federation of Surveyors (FIG) 1994-98, and he is an Honorary Member of FIG. He has undertaken consultancies for the World Bank and the European Union especially in Eastern Europe and Sub Saharan Africa. He has more than 250 publications to his credit, and he has presented invited papers to more than 60 international conferences. For further information and a full list of publications see http://www.land.aau.dk/~enemark

CONTACTS

Professor Stig Enemark
FIG President
Aalborg University, Department of Development and Planning
Fibigerstrede 11, DK 9220 Aalborg
DENMARK
Tel. +45 9635 8344; Fax + 45 9815 6541
Email: enemark@land.aau.dk
Web site: www.land.aau.dk/~enemark

ABET Accreditation Criteria for Surveying/Geomatics Programs in the US

Steven FRANK, USA

Key words: professional education, accreditation

SUMMARY

The Accreditation Board for Engineering and Technology (ABET) is an association of US professional societies that sets criteria that are followed by many of the US surveying programs. The American Congress on Surveying and Mapping (ACSM), one of the two members of FIG, is a member of ABET. ABET consists of commission that oversee different types of programs. The 4 commissions within ABET are the Engineering Accreditation Commission (EAC), the Applied Science Accreditation Commission (ASAC), the Technology Accreditation Commission (TAC) and the Computing Accreditation Commission (CAC). In the US, 4-year surveying programs have been accredited under EAC, ASAC, and TAC. It is anticipated that some US GIS programs may seek ABET accreditation under CAC.

Although ABET is a single organization, each commission sets individual criteria. Within each commission, each member professional society is responsible for setting program criteria within its disciplinary areas. The commission and program criteria are substantially the same in form, but differ in specifics.

One of the purposes of ABET accreditation is to ensure that minimum criteria in professional education programs are being met. This set of criteria is especially important to licensing boards in the several states. Beginning in 2001, ABET has also reviewed non-US surveying/geomatics programs for substantial equivalence. The Geomatics Engineering program at the Technische Universiteit Delft in the Netherlands was judged by ABET to be substantially equivalent in 2001. The Geodesy and Photogrammetry Engineering program at King Fahd University of Petroleum and Minerals in Dhahran, Saudi Arabia was qualified as substantially equivalent in 2005.

1. INTRODUCTION

In the US, there are two levels of college or university accreditation: institutional accreditation and program accreditation. The institutional level accredits colleges and universities. Under institutional accreditation, the entire college or university system is reviewed and accredited. The institution accreditation is most often performed by a regional association of colleges and universities. Program accreditation centers on specific programs of study. Program accreditation is normally done through associations of professional societies. ABET, Inc. is the recognized accrediting agency for applied science, computing, engineering and technology programs in the US. It is an association of 28 professional and technical societies which currently accredits over 2,700 programs in over 550 universities and colleges in the US. Those surveying and geomatics programs accredited in the US are accredited under ABET.

The accreditation process has evolved from a set of criteria where individual coursework was defined to a more flexible set of criteria where programs must define educational objectives, set program outcome goals, and then prove that those goals have been met. The reason for the change was to allow programs more flexibility in improving and refining their individual programs to meet the needs of those who hire program graduates.

2. THE ABET ACCREDITATION PROCESS

Under ABET a program must have produced at least one graduate to become eligible for accreditation. Each program wishing to become accredited must request a formal review. The review process consists of a written document, known as a "self-study questionnaire" and is provided by the program wishing to become accredited. Next, the document is reviewed and one or more people are assigned to perform an evaluation site visit to the institution where the program exists.

The site visit normally lasts 3 days. The evaluator is expected to read the self-study questionnaire prior to the visit, then to investigate any perceived problems with meeting program criteria. Some questions may be resolved by email or telephone correspondence prior to the site visit. When on-site, the evaluators will review student transcripts, student projects, student examinations, classrooms, and laboratories. Evaluators will also interview administrators, faculty, students and, if available, graduates and employers of graduates. Evaluators are volunteers from industry and academia who undertake periodic review in evaluation criteria and training in evaluation protocols. Evaluator expenses are reimbursed by ABET which charges the program being accredited a set fee for the process.

Each program is accredited on its individual merit. If more than one program exists within a department or a college, then each program is accredited separately. It is recognized that there are common elements for programs within a college or department and the institution where programs are being accredited may provide one institutional report that covers several individual programs being evaluated. The criteria for each of the ABET commissions is discussed below.

3. THE EAC ACCREDITATION CRITERIA

To become accredited under the Engineering criteria, a program must have the word "engineering" in its degree. Engineering programs are accredited based upon 7 general criteria: Students, Program Educational Objectives, Program Outcome Objectives, Professional Component, Faculty, Facilities, and Institutional Support and Financial Resources. In addition, each program must satisfy applicable program criteria. The program criteria add to or enhance the general criteria and are generate by the ABET professional society member associated with the particular discipline being accredited.

EAC programs must demonstrate that students are being evaluated on performance, being advised on academic and career matters, and that they are being monitored to assure success as graduates. There must be policies for students transferring credit from other programs or institutions and policies to ensure that each student meets all of the program requirements. There must be demonstration that these policies are being enforced. Demonstration can be partially shown by exhibit at the time of the evaluation site visit of student examinations, projects, portfolios, and transcripts. Tracking of student success on standardize national and state licensing examinations also can demonstrate that this criterion is being met. Generally, a program self-study report will outline the procedures, methods, and policies being used and offer to exhibit other material at the request of the site evaluator.

Program Educational Objectives describe the career and professional accomplishments that program graduates are expected to achieve. As a general rule, graduates would be expected to be able to achieve these objectives within 3 to 5 years after graduation. An example of an Educational Objective would be that graduates are able to become licensed as professional surveyors after 4 years. The Program Objectives must be published and they must be consistent with the institutional mission. The program must demonstrate that these objectives are periodically reviewed and evaluated and that a process is in place to use the results of the evaluation to develop and improve the objectives.

Program Outcomes and Assessment relate to the skills and knowledge that students acquire within the program. This criterion is directly related to the program curriculum but does not specify specific types of courses that students must take. Instead, it lists specific outcomes that students must be able to achieve by following the program curriculum. These outcomes include:

(a) an ability to apply mathematics, science, and engineering principles;
(b) an ability to design, conduct and analyze experiments;
(c) an ability to design a system, component or process given real-world constraints;
(d) an ability to function on multidisciplinary teams;
(e) an ability to identify and solve problems;
(f) an understanding of professional and ethical responsibilities;
(g) an ability to communicate effectively;
(h) a broad education covering economic, social, and environmental issues;
(i) a recognition of the need to continue life-long learning;
(j) a knowledge of contemporary issues;
(k) an ability to use the knowledge, skills, and modern tools necessary for professional practice.

Known as ABET a-k, these outcomes must be demonstrated within the program curriculum. This can be demonstrated by listing one or more specific a-k outcome in a course syllabus and collecting student data from the course measuring the outcome.

The Professional Component also directly relates to the program curriculum. The Professional Component requires that each program consist of a minimal amount (one year) of mathematics and science coursework, a minimal amount (one and one-half years) of engineering coursework and have a general education component that complements the other two components. This criterion also requires the program to demonstrate that students are prepared for professional practice by having each student become involved with a major design experience specific to the profession in which the student relies on knowledge and skills learned within the curriculum. The project must incorporate realistic standards and have real-world constraints. An example of this last would be to have students prepare a land development design using state standards and given local economic, political, and social constraints. Finally, a Surveying specific program criteria requires each Surveying or similarly named program graduate have proficiency in one or more of the following areas: boundary/land surveying, geographic/land information systems, photogrammetry, mapping, geodesy, remote sensing, and other related areas. The other related areas are left to the interpretation of the program and the program’s eventual evaluator.

The Faculty criterion requires that there must be sufficient faculty members with the proper competencies to teach all of the curricular areas of the program. There must be sufficient faculty to adequately interact with student instruction, advising, and professional development. The program may demonstrate faculty competence by listing factors such as faculty education, professional and teaching experience, faculty involvement in professional societies, and faculty licensure as professional surveyors. Again, a program specific criteria requires that faculty members who teach courses that are design in nature demonstrate competency by virtue of professional licensure or by education and design experience.

To satisfy the Facilities criterion, the program must demonstrate that adequate classrooms, laboratories, and equipment are available to accomplish the program objectives and provide an atmosphere conducive to learning. Programs must provide students access to modern equipment and computing facilities. As a general rule, classrooms must be comfortable and equipped with blackboards, white boards, and/or projectors that enable effective teaching methodology, equipment must be modern and reliable, computer software must be relevant and useful. It is not necessary that the program own all of the equipment and computers needed, but that it can demonstrate adequate access to the equipment and computers. In some programs starting up, the equipment can be (and often is) borrowed through agreements with the local professional society or individuals with an interest in seeing the program succeed.

Finally, the program must demonstrate that it is receiving adequate institutional support, financial resources, and leadership to assure the continued quality of the program. The resources must be sufficient to attract and retain well-qualified faculty and to acquire and maintain adequate facilities and equipment to support the program. Other support, such as computer technicians, library resources and student services must be adequate to meet the program needs.

Surveying/geomatics programs currently accredited under EAC criteria include:

California State University, Fresno (BS in Geomatics Engineering)
Ferris State University (BS in Surveying Engineering)
University of Maine (BS in Spatial Information Science and Engineering)
New Mexico State University (BS in Surveying Engineering)
Ohio State University (BS in Geomatics Engineering)
Pennsylvania State University, Wilkes-Barre (BS in Surveying Engineering)
Purdue University (BS in Land Surveying Engineering)

4. THE ASAC ACCREDITATION CRITERIA

The Applied Science program criteria is similar to the Engineering program criteria. There are the same 7 general areas listed along with discipline-specific criteria. The differences between ASAC and EAC criteria relate primarily to the engineering component of the program. ASAC programs are not expected to demonstrate adherence to the criteria at the engineering standards required by EAC programs.

Under ASAC there are no requirements to demonstrate that students or graduates are capable of engineering design. The ASAC accredited program must still demonstrate student advising and monitoring, program educational objectives, program outcomes and assessment, a professional component, adequate faculty, adequate facilities, and adequate institutional support. There is still an ABET a-k component, however it does not require demonstration of engineering design capabilities nor is there a requirement for a culminating class involving real-world design.

The Professional Component under ASAC differs from the EAC criterion by not giving specific guidelines on the minimal amount of mathematics, science and other courses that must be taken. There is still a requirement for three components: 1) mathematics and science, 2) applied science topics, and 3) general education. ASAC programs must still provide students with some sort of capstone experience where students incorporate acquired knowledge and skills into solving a real-world problem. The program specific criterion for surveying programs is the same as under EAC. Program faculty need not demonstrate design experience and can prove competence through applicable certifications as well as education, experience and licensure.

Programs currently accredited under ASAC criteria include:

University of Alaska Anchorage (BS in Geomatics)
East Tennessee State University (BS in Surveying and Mapping)
University of Florida (BS in Geomatics)
Metropolitan State College of Denver (BS in Surveying and Mapping)
Michigan Technological University (BS in Surveying)
Oregon Institute of Technology (BS in Geomatics)
Southern Polytechnic State University (BS in Surveying and Mapping)
St. Cloud University (BS in Land Surveying and Mapping Science)
Texas A&M University, Corpus Christi (BS in Geographic Information Science)

5. THE TAC ACCREDITATION CRITERIA

Under Engineering Technology programs, accreditation criteria is primarily the same as EAC and ASAC criteria with the differences noted as listed below. There is not a specific student criterion in which the programs must demonstrate the level of advising and monitoring performed under EAC and ASAC criteria. There is still a requirement for Program Educational Objectives and Program Outcomes, including the ABET a-k outcomes. The differences in the a-k outcomes require TAC graduates to demonstrate mastery of knowledge, techniques, skills and modern equipment. The emphasis in TAC programs is more "hands-on" learning.

Instead of a Professional Component, TAC has a comparable criterion called Program Characteristics. These Program Characteristics require than 4 year programs have a minimum 124 semester hours of credit or 186 hour quarter hours of credit. There is a requirement for mathematics, including calculus, and science coursework as well as social science and humanities coursework. The programs must demonstrate that their students are capable of appropriate communication skills. The technical content of the program must focus on the applied aspects (hands-on skills) of science and engineering and must constitute at least one-third of the curriculum content and should not exceed more that two-thirds of the curriculum content. Students must still have a capstone experience incorporating accumulated knowledge and skills. Surveying specific curriculum criteria require baccalaureate programs to provide skills normally necessary for professional licensure.

Under TAC, faculty must have sufficient responsibility and authority to develop and achieve program objectives. The criteria for Facilities and Institutional Support are similar to those under EAC and ASAC.

Those 4 year surveying programs currently accredited under TAC include:

The University of Akron (BS in Surveying and Mapping Technology)
Alfred State College (BS in Surveying Engineering Technology)
Idaho State University (BS in Geomatics Technology)
New Jersey Institute of Technology (BS in Engineering Technology)

In addition, several 2 year surveying programs are accredited under TAC:

The University of Akron (AAS in Surveying and Mapping Technology)
Alfred State College (AAS in Surveying Engineering Technology)
Greenville Technical College (AS in Geomatics Technology)
Mohawk Valley Community College (AS in Surveying Technology)
Paul Smith's College (AS in Surveying Technology)
Pennsylvania College of Technology (AS in Surveying Technology)
Pennsylvania State University, Wilkes-Barre (AS in Surveying Technology)

As can be noted from the above listing, institutions can offer a surveying program at more than one level and under more than one set of criteria. Institutions that do so must demonstrate that the criteria of each accredited program are met independently although the students from the two different programs may sometimes sit in the same classroom in the same course.

6. THE CAC ACCREDITATION CRITERIA

ABET Computing Program criteria are the most different from the other commission criteria. Under CAC criteria programs must still demonstrate documented, measurable objectives and outcomes. They must also still demonstrate that measures are being evaluated and those evaluations used for continuous improvement. However, specific wording regarding students requires that the program demonstrate that students can graduate in a reasonable time, and that courses are offered with sufficient frequency for students to graduate in a timely manner.

CAC accredited programs must have sufficient faculty members to provide program continuity and stability. Full-time faculty must oversee all course work and cover most of the classroom instruction. Some faculty must be PhD level while others must have work at least comparable with a Master's degree.

The curriculum for CAC programs must include at least 40 hours of computer science topics, 30 hours of humanities topics, 15 hours of mathematics (including discrete mathematics, calculus, statistic, and probability) and 12 hours of science (including a 2 course series lab science sequence). Students must be exposed to a variety of computer programming languages and must become proficient in at least one higher-level programming language. Students must have adequate access to the systems needed to learn in each course and there must be adequate technical support to maintain the computing facilities.

To date, there are no surveying/geomatics programs accredited under CAC.

7. CHOOSING AN ACCREDITATION CRITERIA

Many of the following observations are personal although I have discussed these observations with colleagues familiar with ABET and have not received any serious dissent from them. I apologize in advance if I inadvertently offend anyone connected with ABET with these observations.

Surveying programs choosing ABET accreditation must decide on which set of criteria they wish to follow. We will concentrate on the EAC, ASAC, and TAC accreditation as there are currently no survey/geomatics programs accredited under CAC. The curriculum content varies across the commissions and is one factor in selecting a venue for accreditation. The emphasis on math, science, and design is most stringent at the EAC level and appears to lessen at the ASAC level and lessen even more at the TAC level. The emphasis on the curriculum tends more towards theory at the EAC level and more towards practice at the TAC level.

The qualifications for faculty also appear to follow the same pattern and are a second factor in selecting a given course of accreditation. The faculty at EAC programs are primarily PhD-level. It would be difficult for a person without at least a relevant Master's degree to qualify as full-time faculty in EAC programs. There are still mostly PhD-level faculty at ASAC programs, but this is much less of a concern in TAC programs. There is probably more emphasis on faculty research under EAC programs, less emphasis on research under ASAC programs, and even less under TAC programs. While there are exceptions to these observations, they appear to generally hold true.

The constituents (students, alumni, employers of alumni) are a third, and perhaps most important, factor. Employers looking to hire graduates with good practical skills coming directly from college would probably tend to want to hire graduates from TAC schools.

Employers looking to hire graduates with abilities to tackle complex problems involving significant analysis and application of theory would probably tend to hire EAC or ASAC graduates. Federal agencies tend to rank employees with EAC accredited degrees at a higher rate than those with non-EAC accredited degrees and can become a factor. In some states, surveyors are allowed to do more engineering-related work, such as drainage and sewer design, while in others surveyors are restricted to more typical survey tasks such at property boundary line determination, mapping and construction activities. In those states allowing more engineering content among the surveyor's duties, there is more of a tendency to have an EAC accredited program. A major factor in showing that the program is successful is to track the number of graduates from the program that are working within the profession in which they were taught.

Student recruitment and retention may also be factors in selecting a set of criteria. While geography is probably the most important factor in choosing a particular program, students have indicated that they selected one school over another because of the reputation of the faculty, the perceived strength of the program, and even the program name. One student indicated that he chose New Mexico State University over a much closer institution because the degree name contained "Surveying" rather than "Geomatics."

As programs change, they may select to change their accreditation. Schools that are EAC accredited may apply to become ASAC accredited and *vice versa*. There are instances where surveying/geomatics programs are accredited under more than one commission, sometimes occurring as an overlap when changing accreditations but also occurring when two interconnected programs at 2-year and 4-year levels appear at the same institution sharing curriculum, faculty and facilities. Pennsylvania State University at Wilkes-Barre is an example of this occurring. While it appears that any survey/geomatics program could become accredited at all three levels simultaneously, cost and time appear to discourage most from doing so since each commission requires a separate self-study report and a separate onsite visit for evaluation.

8. CONCLUSIONS

ABET is the agency accrediting most surveying/geomatics programs in the US. ABET consists of EAC, ASAC, and TAC commissions under which surveying/geomatics programs may opt to become accredited. The criteria guidelines examine at students, faculty, facilities, support and curriculum content. A major factor in achieving accreditation is showing that graduates from the program are being hired to work within the profession in they were taught.

The criteria for accreditation under each commission varies and is a strong factor in determining which direction a program may chose to select when applying or reapplying for ABET accreditation. Employers of graduates may also have a strong influence on accreditation based upon the levels of knowledge and skills they wish prospective employees to possess. Programs may change their accreditation status from one commission to another.

REFERENCES

ABET, http://www.abet.org/

BIOGRAPHICAL NOTES

Dr. Steven Frank is an Associate Professor and Coordinator for the Surveying Engineering program at New Mexico State University. He is a graduate of California State University, Fresno (BS, MS) and the University of Maine (PhD 1994). He has been licensed as a Land Surveyor since 1980. His work experience includes property boundary surveying, construction surveying, control surveying, and photogrammetry. He has worked in California, Maine and New Mexico as well as in Saudi Arabia.

Dr. Frank has served as President of the New Mexico Professional Surveyors and President of the American Association for Geodetic Surveying as well as on numerous committees and boards. He was selected as the New Mexico Surveyor of the Year for 2007 by the New Mexico Professional Surveyors.

CONTACTS

Dr. Steven Frank
New Mexico State University
PO Box 30001, MSC 3566
Las Cruces, New Mexico 88003
UNITED STATES OF AMERICA
Tel. +01-505-646-8171
Fax + 01-505-646-1981
Email: sfrank@nmsu.edu
Web site: survey.nmsu.edu

Reuse and Sharing of e-Learning Materials inside the EU

Tamas JANCSO, Hungary

Key words: e-Learning, curricula, education, geoinformation/GI

SUMMARY

The paper deals with the principles of the methodology concerning the reuse and sharing of the existing learning materials among the universities. The paper demonstrates the theoretical issues through the eduGI (Reuse and Sharing of e-Learning Courses in GI Science) project and gives an example for an e-Learning material under the topic of the "Data acquisition and integration" course developed by the University of West Hungary, at the Faculty of Geoinformatics. The paper explains the idea how to (re)use existing resources by the exchange of e-Learning courses via Internet and it lists the benefits of such kind of action.

1. INTRODUCTION

There are many efforts worldwide in the creation of e-Learning modules and learning environments (Farell 2001). Although e-Learning increases the efficiency of education, the investment of resources is not very effective, many developments are running in parallel. If we focus on the re-use of existing resources and the more effective use for future developments, e.g., updating teaching materials, we can utilize the *virtual mobility* with better efficiency. By the practice the adaptation of the existing learning materials usually means the adaptation to English language or using concepts and digital teaching materials of existing regular courses.

2. METHODOLOGICAL ISSUES

2.1 Course development

2.1.1 Importance of the syllabus

The syllabus as a document with an outline and summary of topics to be covered in a course is a key factor for the success of any e-Learning course (Markus 2004). Within eduGI please refer to the following example:
http://edugi.uni-muenster.de/eduGI/downloads/08/teaching_materials_UWH_data_acquisition_and_integration.zip).

In the syllabus the following topics should be described:

- Contacts

  Giving the full name, photo, e-mail and other data of contact persons. Here the teacher, tutor and administrator positions should be distinguished.

- Goals

  This section introduces the aims, learning outcomes, skills, competences, the main topics, methods and principles of the course delivery.

- Contents

  Here the course content is described using the structure of “parts – modules – units” hierarchy and the explanation about the characteristics of the material is introduced here as well. It is useful if we try to group the modules into “Parts” by the logic of whether they targeting theoretical, practical or analytical skills. Here is as an example of the above mentioned course:

As it is seen from the list, that the modules are divided into smaller parts called learning units. By this approach we give for the students a clear overview about the content and they can plan their activities in smaller portions, which is very useful if we consider that a typical e-Learning student has shorter time at once for a short period only and hence he/she prefers to acquire the learning material in small portions.

- Methods

  Here we should list the key issues necessary for the successful completion of the course. Typically here is mentioned the methods of communication and exam, the expected workload, etc.

- Participants

  In this section the primary target group as potential students together with the pre-requirements should be described exactly.

- Organization

  This part mainly is about the time schedule, indicating the duration, the date of the synchronous sessions, the date of the final exam. Also here is mentioned the planned number of participants.

- Successful participation

  In this section the clear regulations for the successful completion of the course are given. Even the list of tasks together with the deadlines can be listed here.

- Course preparation

  Here are listed all the steps which are necessary to start the course. Typically it means that we should organize a test of synchronous session and provide (upload) the learning material to the e-Learning platform, or as an option we can provide some off-line materials (books).

- Literature

  This section contains the list of the required and recommended literature and other useful optional learning materials.

2.1.2 Course content

If we want to re-use and share the teaching material in an e-Learning environment we have to put some efforts on the conversion and update based on our existing material. Here we can meet the following tasks:

- Adaptation to other language (e.g. Hungarian-English).
- Conversion of plain texts into ppt or other multimedia presentations.
- Development of demo software for carrying out the practical tasks through Internet (for example a program for coordinate translation between different systems).
- For self assessment we need to work out tasks, assignments. When we think out the assignments we need to consider the amount of time planned for the given module, otherwise the students will not be able to complete each task.
- We need to plan the synchronous sessions and for this we have to prepare special interactive aids (e.g. video, interactive software usage tutorial, etc.)

3. ORGANIZATIONAL ISSUES

3.1 E-Learning platform

3.1.1 Available tools

An appropriate e-Learning platform for the given e-Learning course should be chosen carefully. Mainly there are two options. A platform can be developed using the available open source tools (e.g. MOODLE) or a license (e.g. Blackboard) should be purchased. Each choice has its own advantages and disadvantages. If a “in-house” way is chosen, there would be necessary to employ not only web masters but also programmers, or at least professionals who can utilize all the aspects of an open source environment, which is typically based on Linux logic. But on the other hand the system can be accommodated for the user’s needs deeply (Markus 2001), (Katz 2002).

If the off-the-shelf version is chosen the operating institution needs only administrators who can operate the system and in this case only the built-in functions can be utilized.

On the other hand I need to add that these systems are well tested and the built-in functions are assuring a stable operation.

Usually an e-Learning platform should offer at least the following tools (see also Figure 1.):

- Communication with the students (e-mail, voice-mail, announcements)
- Discussion board
- Tools for synchronous sessions
- At the course delivery: handling of different file formats like html, ppt, pdf, doc, mp3, etc.
- The assessment facilities like test manager, upload of tasks.
- Course calendar
- Gradebook, course statistics

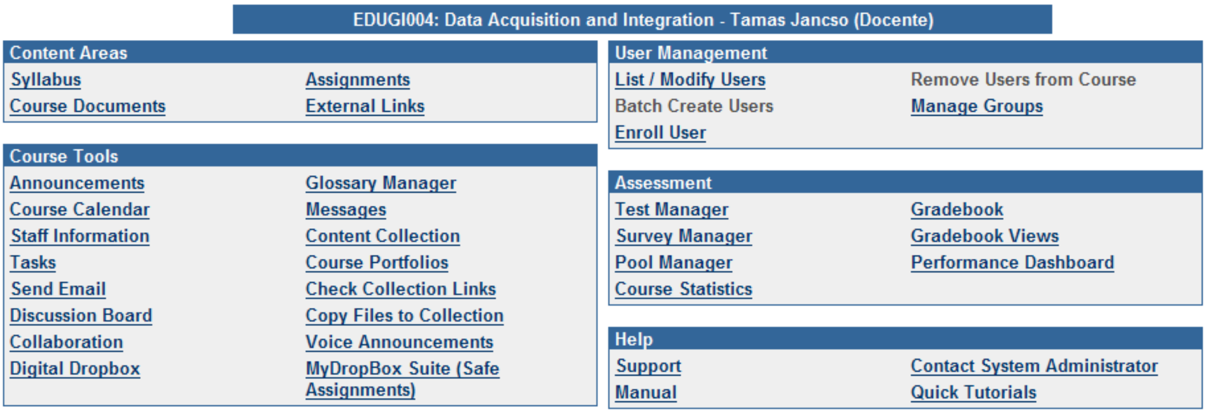


Fig. 1: Control panel of the Blackboard e-Learning platform

3.1.2 Synchronous sessions

The synchronous sessions are the central part of each e-Learning course. At these sessions the students have possibility to ask directly the tutor and it is a good possibility for the tutor to survey the common problems and the opinion of students as well. Here the tutor can explain some parts of the course which are too complicated to describe in off-line manner.
As it was experienced this method of teaching needs a lot of time from the tutor to be prepared for it. Not only because of the students can ask any aspect from the material, but also because of it needs a good practice from the tutor not to lose the main stream in the material, since the students usually ask about those issues which are not discussed in detail in the teaching material. Especially we should avoid those students who want to test the knowledge of the tutor, since it's boring for other on-line session participants who usually want to concentrate instead on the assignment issues.

3.1.3 Final exam

The final exam of an e-Learning course is a sensitive part, since usually the students should be virtually collected in the same time. But in general there are mainly two options for the organization of the final exam. The exam can be organized in the frame of a synchronous session, which is very useful since the tutor can ask to form small groups during the exam asking them to solve more complex tasks. Also the tutor can help the students if they don't understand the task or they stuck somewhere in the practical task. The only negative aspect of this type of exam is that some students - who miss this synchronous session - are not able to pass the exam at all. In this case the tutor should consider the possibility to give a chance to take the exam off-line with the help of the local partner tutors of the student's institution.
The other effective method for the final exam is a test session which is open for a limited time (usually 24 hours). In this case each student can find a time window to complete the test. For those who has no time at all in the announced time-frame, the tutor can allow and assign for each student an individual date for the exam.

4. EXPERIENCES

In the eduGI project (EU eLearning Programme ref. EAC/23/05 DE 011.) eight European GI institutes use existing courses and adapt them to the requirements of the e-Learning course exchange. Each partner contributes one course, to be taught on a non-profit exchange basis with the partners. An e-Learning platform of ISEGI-UNL, Portugal is used. This platform has been successfully providing an e-Learning MSc Program in Geographic Information for more than three years. During a previous work in the ALFA project eduGI.LA (www.eduGI.net/eduGI.LA/) a prototype was developed for the e-Learning course exchange and evidenced feasibility. The organizational framework for execution and recognition of students' achievements was prepared by the cooperation of the eduGI.net consortium (www.eduGI.net).

5. CONCLUSIONS

The development and exchange of the following eight e-Learning courses is foreseen: Project management, GI standards, Advanced Geospatial data mining, Data acquisition and integration, Visualization, Geographic data bases (advanced), Virtual excursions in Earth Sciences, Data quality.

The vision is to exploit the organizational framework and the created e-Learning courses by the establishment of a common, virtual GI Master Program in Geoinformatics. The concept of sharing and reuse of resources by best-practice examples is being disseminated to non-GI communities.

Additional expected benefits:

- The quality of the existing teaching material will be improved further.
- There will be possibility for access to international know-how and new topics, that is normally not available for students by own resources.
- The virtual mobility of teachers and students can be improved.
- It contributes to the implementation of the Bologna process by international cooperation of European institutes, based on the existing networks.

The results of the eduGI project can be utilized in Working Groups of the curriculum development and e-Learning work plan at FIG Commission 2.

ACKNOWLEDGE

The eduGI project (eLearning Programme ref. EAC/23/05 DE 011.) is founded by EU. Acknowledgement is expresses to eight European GI institutes for their valuable participation in the project. See the site: http://www.edugi.net/eduGI

REFERENCES

1. Farrell, G. M.ed. (2001): The Changing Faces of Virtual Education, The Commonwealth of Learning, Vancouver, British Columbia, Canada.
2. Katz, R.N. ed (2002): Web Portals and Higher Education, A publication of EDUCAUSE and NACUBO, Jossey-Bass, San Francisco, USA.
3. Márkus B. (2001): Networked education in land administration, FIG Working Week, Seoul, pp. 146-147.
4. Márkus B., (2004): Curricula development in Bologna Process, FIG Working Week, Athens.

BIOGRAPHICAL NOTES

Dr. Tamas Jancso gained his MSc degree in 1990 at the University of Geodesy and Cartography in Moscow at the Faculty of Aerial Surveying (with honored diploma). Working now as an associate professor and vice-dean at the Faculty of Geoinformatics of the University of West-Hungary at the Department of Photogrammetry and Remote Sensing. Thirteen years of experience in teaching of photogrammetry and photo-interpretation. Staff member in the formation of open and distance learning facilities at the faculty, co-author of two distance learning modules. He has experiences in using digital photogrammetric workstations. In 2006 he gained the Ph.D. degree in the topic of "Photogrammetric application of nonlinear models in geo-environmental sciences".

CONTACTS

Dr. Tamas Jancso, Vice-dean
Faculty of Geoinformatics
University of West Hungary
Pirosalma u. 1-3
P.O. Box 52
H-8000 Szekesfehervar
HUNGARY
Tel. + 36 22 516 543
Fax + 36 22 516 521
Email: jt@geo.info.hu
Web site: www.geo.info.hu

Google Summer of Code in Geoinformatics

Jan JEŽEK, Czech Republic

Key words: project-based learning, gis, geoinformatics, google summer of code, open source

SUMMARY

Google Summer of Code (GSoC) is a program that offers student developers stipends to create new open source programs or to help currently established projects. Google is working with a variety of open source, free software, and technology-related groups to identify and fund several hundred projects over a three-month period. GSoC is program focused on students from the whole world who are working on projects used by real software products and finally they are accordingly honored.

This year it was the first time when there were also projects focused on geographic information systems **(**GIS). This presents also a great opportunity for geoinformatics community to contribute to GIS related software development.

The aim of this paper is to describe GSoC from the project-based learning perspective. Details about communication, time-line and project management will be discussed and also a lot of statistics of participant geographic distribution will be presented. Finally, the present paper also describes author's personal experience (the author participated as a student developer at GSoC 2006 with Refractions Research as mentoring organization) and also deliverables of GSoC for GIS software products.

This paper should promote GSoC as an excellent opportunity for students interested in open source software. GSoC is focused more on creative thinking rather than on repetitive drill and students can learn a lot of new things in very interesting way.

1. HOW DOES GSOC WORK

GSoC usually starts during the spring. At first Google makes an announcement which is addressed to several open source communities that they can join to the program as mentoring organizations and can apply for participating. These organizations delegates their candidate that should participate as mentors and they also prepares project ideas. In 2006 the program joint about 100 organizations. After that the student’s application process starts. Student can write a project proposal on an idea related to the needs of mentoring organization, but also any kind of new idea is welcomed. One Student can write 20 applications at the most, but just one can be accepted. The proposals are then checked by mentors and the chart of received projects is made. Google then decides how many projects will be funded for each organization.

The real coding starts in June. The process is divided into three periods. At first students receive 500USD after their proposal is accepted. After approximately one month of coding their mentors are asked by Google to write the mid-term evaluation of the process that had been done. Usually they check whether the process corresponds with originally proposed time line. If their evaluation is positive, the student receives a 2000 USD check. The programs end in September, when a final evaluation is made and the student receives the last 2000 USD if they succeed.

One of the reasons why Google brings a third party to the project is that mentoring organization knows probably much more about the needs of their communities development and provide better subvention about current development than people from Google. On the other hand Google also acts as a mentoring organization in its own Open Source project.

A mentoring organization should actively encourage each student developer to participate in the project's community in whichever way makes the most sense for the project, be it development mailing lists, idling in the project's IRC channel, etc. A truly successful mentoring organization will work diligently to ensure that as many of their students as possible remain active project participants long after the conclusion of the program.

2. 2006 GSOC STATISTICS

First GSoC was realized in 2005 when Google worked with 40 organizations. In 2006 Google brought together about 100 organizations with 630 students all around the world. The leading organizations that received most of the applications were Google, KDE, Ubuntu, Python Software Foundation and GNOME. Czech Republic was represented by three accept students and three mentors.

Exact statistics for GSoC 2006 are:

- 6388 Applications
- 3044 Applicants
- 1260 Mentors
- 630 Accepted Students
- 456 Schools
- 102 Open Source Organizations
- 90 Countries

3. PROJECTS FOCUSED ON GEOINFORMATICS

In 2006 it was the first time when there were also project focused on Geoinformatics. The organization that offers such projects is called Refraction Research. This organization is focused on PostGIS, uDig and GeoTools development.
Refractions Research received 12 applications and 9 application were selected as doable. Finally the Google chose three that were funded.

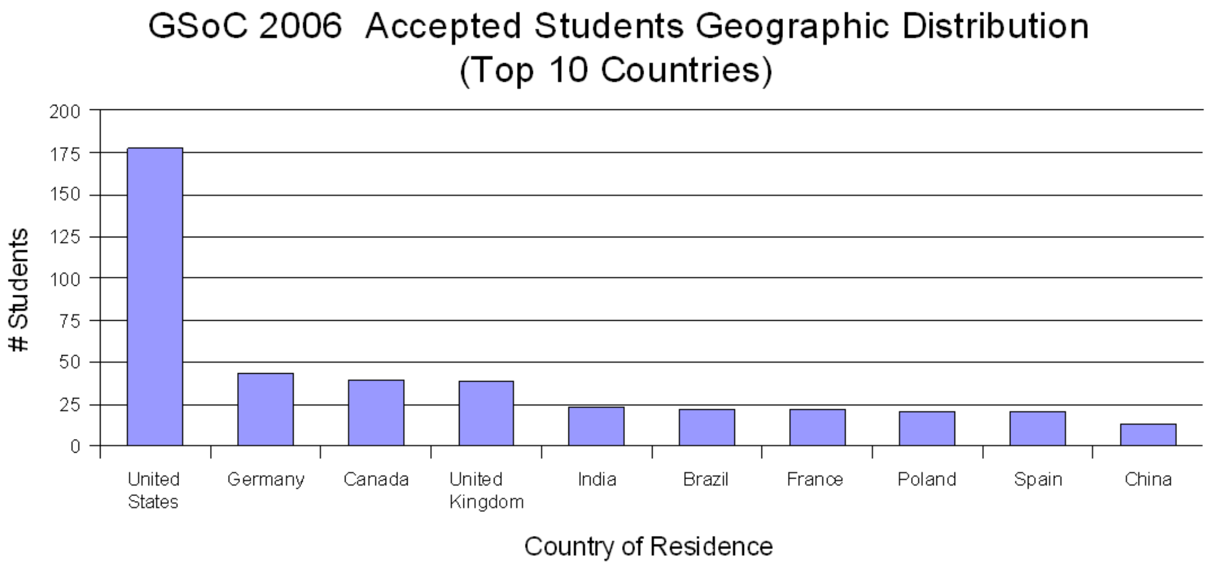


Fig. 1

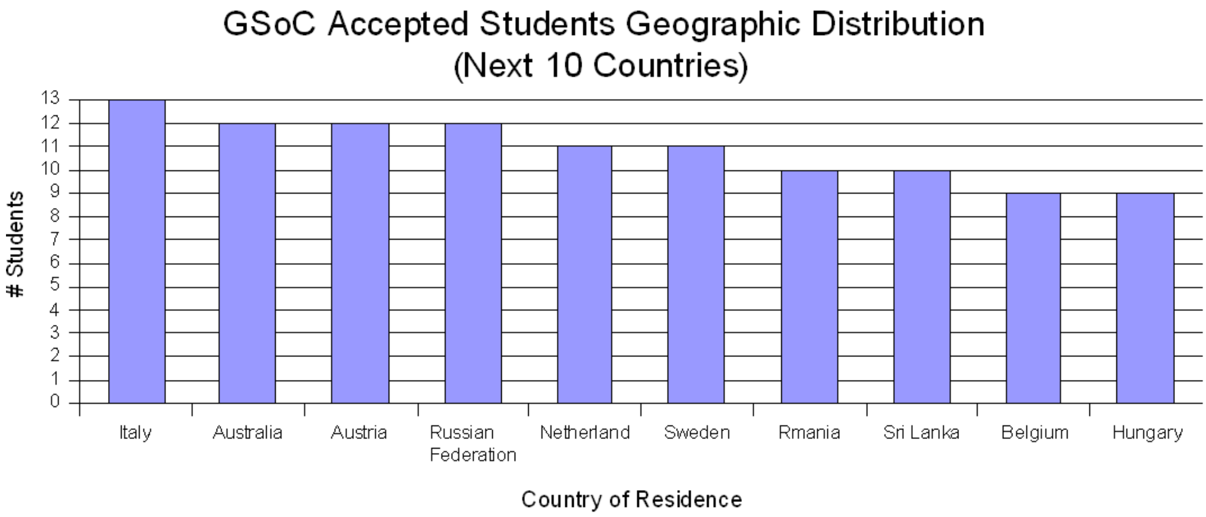


Fig. 2

These project were:

- GDAL ImageIO integration
- uDIG GPS Record Import and Spatial Report Processing
- Coordinate System Transformations for GeoTools and uDig

In upcoming GSoC 2007 most of GIS related open source project are represented by Open Source Geospatial Foundation (OSGeo) so we can expect more project focused on GIS. The mentoring organizations that participate in GSoC 2007 under OSGeo are:

- GDAL
- GeoSever
- GeoTools
- GRASS
- MapGuide

- MapServer
- OpenJUMP
- PostGIS
- User – Friendly Desktop Internet GIS

4. COMPARING GSOC WITH OTHER PROJECTS

In this paragraph I would like to discus my personal experience with GSoC related to other opportunities for students to work on some projects that are available in the Czech Republic (FRVS and Internal Grants Competition at CTU). The main difference is that in GSoC student's work is really focused on the aim of what they have proposed in their application. Usually they have to write weekly reports on the progress they have made and the mentor gives them guidance on what is good and what is not and the mentor is also motivated to produce high quality code as it should become a part of the main product. The communication is realized by emails or some other electronic way. The project is drawn more like full time job for summer (and it is accordingly honored) – final questionnaire shows that students usually spend about 7 hours a day / 5 days a week for three months by coding for GSoC.

The main advantages that I can see is that there is really low level of bureaucracy and the project is 100% focused on real work results. Another strong point is that the project takes place during summer where students are usually trying to find some part time job and maybe that it is more interesting for them to write new module for Ubuntu Linux than to work in the freezer in a supermarket or something like that and in this way they are highly motivated to take part.

GSoC is mostly focused on students of software engineering but statistics from the 2006 show that participants were also students of Mechanical Engineering, English Literature, Interior Design, Astronomy, Developmental Psychology and Genetics. In the dawn of enormous GIS boom GSoC presents also great opportunity for all students of geosciencies.

5. WHAT IS IN FOR GOOGLE

There is good question why Google pays money to students that are working on projects for other companies. There was a very active thread on this topic in the GSoC mail list. The main points why Google does so that have been mentioned by project coordinators were:

- Free and Open Source Software help to ensure competition in the software development market. Competitiveness in software development means that interested parties have incentive to produce high quality code *and* keeps any single vendor from completely dominating a particular market and locking out others out.
- Google uses a lot of Free and Open Source Software - it's no secret that their servers run Linux - and they want to give back to the FOSS communities, particularly since that means Google can continue to use the code that these communities produce to make their products better. (Google also do funding of open source projects outside of GSoC.)

- Google has always looked for talented developers so they can use the results of the program to help identify potential recruits.

6. CONCLUSION

Google Summer of Code is an excellent opportunity for students interested in Open Source to start contributing and get financial support at the same time. They can learn the process of real life software development (software engineering tools like SVN, build tools etc). On the other hand – the applications are accepted according to the idea rather than to the level of their coding skills.

At the time of writing the GSoC 2007 is just ranking new applications so I hope this year will bring even higher level of contribution also for Czech geoinformatics community.

REFERENCES

1. Google. http://code.google.com/soc/, Google Code Home.
2. Refractions Research. http://code.google.com/soc/refract/about.html, Refractions Research GSoC page.
3. OSGeo. http://wiki.osgeo.org/index.php/2007_SoC_Merged_Ideas, OSGeo GSoC page.

BIOGRAPHICAL NOTES

Ing. Jan Ježek is employed at University of West Bohemia, Faculty of Applied Sciences, Department of Mathematics where he works as a lecturer. He is also PhD student at Czech Technical University, Faculty of Civil Engineering, Department of Mapping and Cartography. In summer 2006 he participated in Google Summer of Code as a student developer.

CONTACTS

Ing. Jan Ježek
Institution University of West Bohemia, Faculty of Applied Sciences
Address Univerzitní 22, 306 14
City Plzeň
COUNTRY Czech Republic
Tel. +420 603 313 394
Email: h.jezek@centrum.cz
Web site: http://www.kma.zcu.cz/~jjezek

Education in Geomatics with GRIFINOR

Jan KOLÁŘ, Denmark, Jan KOLÁŘ, Czech Republic

Key words: geomatics professional roles, open-source, 3-D, digital earth, software platform, geographic database, geo-visualization

SUMMARY

The unique properties of geographic information technologies, which are important in many levels of modern society, have crystallized into the definition of a new discipline taught at universities. Education of undergraduate geographers as information technologies professionals however brings in more practical questions such as; what are the most efficient practices in this education; what are the main obstacles when delivering the actual teaching and directing students and how to possibly avoid them? This article aims at answering these questions. A concrete example of project-oriented approach is described, which supports the education in geo-information technology (geomatics). This article is based on the research software platform GRIFINOR for data management, visualization, and exploration of geographic information in three-dimensions. The text introduces the GRIFINOR platform as a modern media technology, which relies on the original task of surveying and mapping redefined in terms of digital content and IT. GRIFINOR's current status is presented, as well as a brief overview of its research contributions in the field of geomatics. In the second part of the article are identified some important obstacles inherent to an education in geomatics. It is explained how GRIFINOR may help to alleviate these obstacles. Freedom in teaching fundamental concepts of the geo-information technology and in studying these elementary components of geomatics with the students is pointed out as an important aspect in this context. An important part of the article also gives concrete examples of skills that students can practice and concepts that can be taught using GRIFINOR. The platform is available as a distribution, which opens opportunities to implement concrete exercises focused on particular concepts of geomatics. The characteristics of the distribution are described in the article. Through the article it is argued that the use of GRIFINOR in education directly supports a number of important roles that, according to related works, need to be played by geomatics professionals. With such properties GRIFINOR is considered as a suitable means for teaching master students in new programmes in geomatics at Aalborg University and at Charles University in Prague.

1. ROLE OF SPECIALISTS IN GEOMATICS

Modern observation and positioning technology eliminated and surpassed the majority of tasks carried out by land surveyors before these technologies became available. Furthermore, a cartographic map can be made today by individuals without a scientific degree using geographical information systems (GIS) with a user interface available on a web page. Taking a different perspective at the situation we can say that some of the most important tasks of land-surveyors and map-makers were replaced by software implementations of the methods, which in the past had to be applied by specialists ”manually” in person. Today, in this field, ”manual” application of the methods cannot match their implementations in the computerized systems, because the technology applies them cheaper, faster and more reliably. Additionally new technologies provide new possibilities, which could never be done in a manual manner.

On the other hand, modern society around the world lacks specialists in basic collection of software technologies, implementations of policies and institutional arrangements that facilitate the use of the huge amounts of spatial data produced by the new technologies. Note that this gap is caused by exactly the same technologies mentioned above---the technologies that weaken the need for traditional land-surveyors and map-makers but open new possibilities in geo-visualization, geographic data infrastructures and other computerized geographic systems. It should be also stressed that the technological advances are based on the very concepts used in the field of land-surveying and map-making itself, that the new technologies became possible thanks to few specialists from our domain. Their contributions led to great improvements in measurements and observations of planet Earth.

To fill up the gap, new study programs in geoinformation technology (*geomatics*) have been established at universities around the world. They are often based on radical changes or are derivatives of programmes in land surveying, mapping and cartography. The primary reason was the fact that graduates of these studies suddenly appeared in the role of mere operators or end-users of new automated systems that came over from other technical disciplines, and which shifted these graduates to a poor position in job competition relatively to the level of specialization they have. But the specialization remains important, maybe even more important than in the past since everything becomes geo-referenced. The problem is how to apply this specialization. ”If we could educate them (students) into information technology professionals, they could have another position in the competition – surveyors would then be not only users of technologies, but rather those who develop both technologies and applications” (Virrantaus 2002). Realization of this arguably logical decision has many impediments and needs real examples, which can be evaluated by others and upon which improvements can be elaborated.

Activity	**Description**
#1 Applications development	Identify and develop tools and instruments to satisfy specific requirements.
#2 Data acquisition	Collect geospatial and related data.
#3 Data analysis and interpretation	Process data and obtain information required for efficient decision-making process.
#4 Data management	Catalogue, archive, retrieve, and distribute geospatial data.
#5 Visualization	Render data and information into visual geospatial representations.

Table 1. Activities the geomatics professionals should cope with.

In the rest of the article we provide an example of a project-oriented approach to support education that produce professionals in geomatics. The example is based on the research software platform GRIFINOR (Kolar, 2006), which allows data management, visualization, and exploration of geographic information in 3D. Through the article it is argued that GRIFINOR directly supports education of four out of five main activities (see Table 1) professionals in geomatics need to master (MSC and NRC, 2006). Having such properties it is considered as a suitable means for teaching master students in new programmes in geomatics at Aalborg University and at Charles University in Prague. The main parts of the article are structured as follows. Section 2 introduces the GRIFINOR platform in relation to the field of geomatics. Subsequent Section 3 then identifies some important obstacles in teaching geo-information technology and points out how GRIFINOR can be used to address them. An important part of the section is also a concrete exemplification of projects based on GRIFINOR.

2. GRIFINOR PLATFORM

The original idea behind GRIFINOR was to exploit huge amounts of data produced by modern measurement technologies in IT through a system of a "real" virtual reality (VR), where by "real" we want to stress the fact that the source data come from measurements of real features in our real environment on planet Earth. This is in contrast with more traditional use of VR for buildings, orchestras or theatres that do NOT exist on the Earth. This idea evolved from generalization of the task of surveying and mapping as geometric model of the reality, which can be instantly visualized in an interactive 3D scene. Therefore GRIFINOR can be considered as a new 3D media platform, which relies on the original task of surveying and mapping to deliver model of the Earth.

In more technical terms, GRIFINOR is an open source 3D virtual globe platform, written in Java. It allows publishing a geo-referenced 3D model called a modelmap on the Internet and rendering the scene using OpenGL. One can explore such modelmap itself but it is also possible to link different parts of the modelmap with data stored in databases, with analytical functions or with resources available on the Web. Like the content on the Web, the modelmap in GRIFINOR can be build by independent contributors collaboratively in a decentralized manner. The modelmap can be navigated through over network in a 3D scene by users, who can also interact with it in a way suitable for their applications.

2.1 Spatial Referencing

GRIFINOR eliminates the use of cartographic projections from concepts of all elementary parts of the system, including the data representation. Three-dimensional coordinates with origin coinciding with the Earth's centre of masses are used for referencing. The definition of the axes is analogous to the World Geodetic System (WGS), meaning that the z-axis is defined by the North Pole and the x-axis lies in the equatorial plane and points to the Prime Meridian, where the reference pole and the meridian are defined by International Earth Rotation and Reference Systems Service (IERS). For this origin and orientation, three systems of coordinates are used in GRIFINOR when convenient. right-handed Cartesian coordinates [x,y,z] are used for data representation, visualization and spatial indexing. Spherical coordinates [Φ, λ, r] are used for indexing and representation of the geopotential model of the Earth that is described later in this section. Geographic coordinates [φ, λ, H], where H is ellipsoidal height, are currently used only for reporting a position on the Earth to the user. Conversions between these systems were implemented in GRIFINOR.

2.2 Interoperability

GRIFINOR deals with interoperability on the level of programming language instead of strict specification of data structures and formats. It has been decided to keep GRIFINOR independent of any particular standard specification of geographic features and leave the possibility to add suitable data representations for each application independently. Therefore the implementation of GRIFINOR ensures scalability in data representation while keeping the interoperability of the system intact. Since the system is coded in Java, which is an object oriented technology, both the communication protocol and the data representation of features are defined in terms of objects. Using Java abstract class definition for representation of the features ensures the scalability for custom definitions. It allows de-facto arbitrary definitions of features, their meaning, the relationships between them and their functionality. With this in mind, GRIFINOR must be regarded as a platform that supports the definitions of custom data representations and application specific functionalities. This directly addresses activities number three and one in Table 1.

3. GRIFINOR IN CONTEXT OF EDUCATION IN GEOMATICS

There are two major obstacles for study programmes in geomatics. The first one is the number of true specialists in geographic information systems that have an overall understanding of the geoinformation technology. There is apparent lack of these people, which could identify and teach the concepts of geomatics for both further research development and applications in practice. The second obstacle is the difficulty to provide students with the ability to study the technologies freely with as little limitations as possible. It is very difficult to get students deeply involved in studying of a certain tool or device when they cannot use it with full control of the processes.

As a software system, GRIFINOR cannot directly address the first issue. But GRIFINOR does address directly the second issue by being freely available to everyone interested, under LGPL license (FSF, 1999).

It seems that the two impediments are complementary. The groups of researchers and developers who, over decades, have developed and understood the new solutions using software technology are nearly exclusively bound with commercial companies. Proprietary commercial software is a source of profit and therefore a subject of strictly protected know-how keeping hidden specific construction of the software tools. On the other side there is a much larger group of teachers and students of geoinformation systems. Using the commercial software as a teaching tools makes almost impossible for the teachers to effectively explain and for students to fully understand individual tools and procedures of data processing and data management. It mostly leads to production of more or less qualified users of the commercial systems rather than new specialists. This scenario in geomatics needs to be changed and presents serious challenge for education community. With GRIFINOR we try to contribute to this effort.

3.1 Source Code

Bringing GRIFINOR to students relies on breaking the heavily overestimated barrier of source code. Source code tends to be perceived as pure device from programming domain, and so, difficult to deal with for everybody from outside the domain. The truth is that, like mathematical formulation, there can be very complex and long expressions that are difficult to read by experiences scientists, but there can be also very simple ones that everybody with high-school education must understand. In fact, source code should play a vital role at university level programs in geomatics. Like students of programs in journalism work with written text and selected works of literature in order to learn how to report news and produce articles, the students in geomatics should work with scripts and source code of data management software in order to learn how to obtain desired geographic information. These skills are essential for professionals in geomatics but they are also very useful in practice in wide spectrum of professions outside the domain of geographic applications. The journalist students are taught about structures, concepts and techniques from existing works that are fundamental for providing various types of new literature, but they are not required to produce new work-of-art pieces of literature, at least not at the university. In similar manner geomatics students should be taught how to read and navigate through an existing code and use it in order to retrieve the desired geographic information, but should not really be required to code new software algorithms or systems. Subjects from any courses that directly address professional activities #1, #3, #4 and #5 from Table 1 are based on source code, which stands for almost the entire domain. Or, from another perspective, the whole technological part of geomatics has its fundamental concepts in source code, except for data acquisition (activity #2).

GRIFINOR is provided over the Internet in form of source code in Java language. With use of integrated development environment (IDE), preferably Eclipse IDE, the navigation through source code can be explained and demonstrated visually. Individual components are hierarchically organized, and relationships between different functions can be followed through their calls in the same manner as following hyper-links on the web.

3.2 Use of Graphical Interfaces

Graphical user interfaces (GUI) as a (part of) subject to teaching and exercises of essential concepts should be reconsidered and used with care in university level education of geo-informatics. The GUI is a counterpart to the text user interface (command line) and to non-interactive execution of sequence of commands (script, or a program). These three concepts are in many ways complementary and none of them is optimal in all situations.

A GUI is an advanced method to operate and interact with finished software products through different kinds of buttons and text fields. It is used to perform an exact, pre-defined task, for example “to triangulate given set of points”, but hide the internals of the solution. The hidden part is considered unimportant or even disturbing during a production application of the software. This makes GUIs at least controversial in a situation when we want to teach what “to triangulate given set of points” means, or what is behind any other button. Therefore, whenever fundamental concepts of the solution should be explained and understood by students, the use of a GUI should be seriously reconsidered. Relying on GUIs have confusing or even misleading effect on a student because the GUI becomes associated in the student's mind with the solution or in the worse case being considered as the solution, none of which is true. GUIs are meant to be intuitive and their functionality can be explored by users who understand the purpose of a given software product and who know about the overall structure of the GUI for that particular software. Therefore, GUIs can be left as a subject for self studying, for the most part, as it is both too trivial and too product specific for being taught in courses at university. GUIs are definitely convenient for supplementary software such as file manager, word processor, IDE or a drawing tool, which do not cover the central focus of subject geomatics, which is management of geographic information.

On the other hand, written commands seem to be more suitable for analytical approach in geomatics. Sequences of command lines or entire scripts provide significantly more insight into a specific solution, expose nominally individual steps, which can be pointed at and thus be better discussed. They are also exactly written and allow seeing all the steps in a context. On the practical side, command sequences can be easily reproduced, passed around, modified as well as corrected or archived by both students and supervisors.

3.3 GRIFINOR in the Context of Courses and Students' Projects

This section shows examples of how GRIFINOR can be used for education in geomatics. The examples are divided into three parts which address its use consequently for explanation of important concepts during teaching, in projects/exercises about creation of content and in projects about improvement of GRIFINOR itself.

3.3.1 Core concepts

The following section presents basic subjects usually part of the background for graduates of geomatics. Through an implementation of their basic concepts, GRIFINOR can be used to point at and explain the concepts in detail, and if necessary also alter, extend or improve.

1) GRIFINOR uses basic coordinate systems typical for geographic applications. Relations between geographic, spherical and Cartesian geocentric coordinates which constitute the geometric computational core of the system are provided. 2) The GRIFINOR source code also addresses inverse cartographic projections (currently applications of transverse Mercator, such as UTM only) on which the role of cartographic projections can be demonstrated back in original three-dimensional space. 3) The next important aspect implemented in GRIFINOR is spatial subdivision used in indexing, which is a crucial concept for databases with huge amounts of data. GRIFINOR is inherently 3D system but spatial subdivisions in 3D space and their use for visualization queries can be demonstrated as a comparison to widely used 2D cases. 4) Role of convenient data representation (data model) is another basic concept in geomatics covered in GRIFINOR. The system design allows for simple data structures as well as advanced object-oriented representations which can be demonstrated using the system. 5) Students should also know that the reference shape of planet Earth (from which physical heights are calculated) is NOT simple geometry and depends on gravity field of the Earth. Classical representation of geopotential based on spherical harmonics is included in GRIFINOR's source code and the concept of geoid can be addressed with this part of the system. 6) An important part of GRIFINOR as well as of most geographic applications is the

process of presenting data in visual form, which is a primer for all kinds of geo-visualization. 7) The last relatively broad subject that can be demonstrated to students using GRIFINOR is web-based mapping, which usually consists of URL query and reception of a raster image - both can be found in the implementation.

3.3.2 Modelmap-making

The first group of potential projects is about creating content that can be brought to GRIFINOR for visualization purposes and possibly for further interaction. The following proposals might provide some inspiration regarding semester or final projects in geomatics.

1) Methodology for semi-automatic creation of geo-referenced 3D modelmap using scanned floor plans, topographic maps or from vector databases or mere attributes. This project would use 3D modelling tool Blender (www.blender.org). The result would describe a procedure for 3D modelling of geographic features at multiple levels of detail and their consequent loading and geo-referencing into GRIFINOR object database.

2) Collect information about available Web Map Services (WMS) in a catalogue and build a simple function that constructs URL query for a given geographic coordinates and a given service from the catalogue. The result could directly exploit ability of GRIFINOR to drape geo-referenced images on the topographic surface in 3D. This would result in effective 3D application of WMS.

3) Another subject is evaluating the influence of settings for SRTM terrain data loader for GIG surface representation on the resulting geometry of the topographic surface. This would result in a better evaluation of the multi-resolution representation of the topographic surface used in GRIFINOR as well as to its improvements.

4) Data representation of simple geometries, such as plane, cube or sphere using procedural, instantiated and referenced representations (Kolar, 2007) and evaluation of their influence on performance. The result would reveal limitations of the three types of content objects used in GRIFINOR. This would be useful in decision whether application can use data directly from a relational database, such as PostgreSQL/PostGIS, or even reference ESRI ArcObjects.

5) Classification of elementary user interactions with features in GRIFINOR's modelmap. Students would provide descriptions for many useful interactions with different kinds of features and classify them from the most general to most application-specific. Example interactions might be “perform SQL query to relational database system” or “open new web-page at given URL” or mere “hide”. The most general interactions will be included in GRIFINOR platform.

6) Comparison of ontology of CityGML, Industry Foundation Classes (IFC) and SEDRIS international standards. The result would include mappings of the associated data models (XML Schemas) to new definitions in terms of GRIFINOR objects.

3.3.3 Application and System Development

This section provides some examples in order to demonstrate the range of potential projects related to GRIFINOR that might be interesting in geomatics.

1) One example of a project could be use of GRIFIN Perspectives (see Documentation section at www.grifinor.net) in coordination with ”WikiProject Geographical coordinates” of Wikipedia or with a similar georeferencing initiative available on the web. This subject could extend GRIFINOR's capability being launched from a web page by a richer interconnection with the content from the web.

2) Experimentation with georeferenced multimedia sources such as video and audio data inside the GRIFINOR scene is another example of student working. The ability of having video and sound rendered in the 3D scene could be explored in this topic. Although it is technically possible today, a work must be done about the best way to prepare, store and structure the data.

3) One project could deal with comparison of various data representations for linear or very long features. Multi-resolution representation of lines is crucial for features such as shorelines, break-lines or roads in general. This subject has relationship to cartographic generalizations and solution would have use in many specific applications.

4) Regarding visualization, there is a topic of influence of different rendering parameters (e.g. lighting, colour properties or polygonal representation) on the resulting geo-visualization effect in 3D scene. This would result in a distinction of different human perceptions of the image and potentially also classification of these perceptions in the context of geo-visualization in 3D and with respect to the standard parameters used in computer graphics.

5) Motion through the scene is a different challenge. Concepts of path definition and transition of camera between predefined perspectives in the geo-referenced 3D scene, would allow for video guides, place presentation or mission rehearsal applications. This would result in definition of new custom navigation moves, which might be useful for navigation in specific situations.

6) In GRIFINOR was implemented classical model of geopotential used in geophysics. However it would deserve to elaborate a better integration of the current representation of the topographic surface. This could result in a direct access to normal heights along with geometrical heights and it could also involve access to other quantities in relation to the geopotential model, such as acceleration, gravity anomaly, or deflection of vertical.

7) Another challenge would be to collect methods for solving coordinate geometry problems in civil engineering and land surveying (COGO functions). Result would demonstrate conventional surveying techniques and instrumentation dealing with coordinates of points, distances and bearings between points associated with identifiers and descriptions. This could also demonstrate standard field surveying procedures, such as a traverse or a series of layout measurements. Value would be primarily educational demonstration of a”virtual land surveyor”.

8) Last example for GRIFINOR related topic might be bringing more inverse map projections aside currently available transverse Mercator. The result could demonstrate their effects during education but also for exploit GRIFINOR's ability to instantly drape satellite and topographic maps on the three-dimensional representation of the topographic surface.

3.4 Proprietary Software in Education

GRIFINOR has been developed as software that could be used freely by anybody interested in the implemented solutions. It is considered that universities have a duty to use such kind of software for three reasons. The first reason is that master programmes should direct students on the path to self reliance and NOT to become users of proprietary software. Therefore study programmes in geomatics should NOT teach any software products that might be constraining or even unavailable for their graduates in practice. The second reason for free software at universities is regarding the quality of education, because with proprietary software one cannot explain the exact internals of the system even if it is an essential or otherwise interesting concept. One also cannot direct interested, talented students to study certain aspects deeper because those details are secrets that nobody at the university can know about. The third reason is to save money as it costs money to pay regularly for licenses of proprietary systems. Every school system we know of is pressed for money. But even if commercial companies give out a free sample of proprietary software for students the offer should be re-considered because the reason to put out the samples are exactly the same why other companies giving away free samples.

GRIFINOR is one from a large family of software that guarantees freedoms in its users and legally enforces these freedoms through its license. Once you get GRIFINOR or other software under LGPL license you can use it any time in the future for any private or commercial purposes, but whenever you will want to provide it to others it must be under the same terms. GRIFINOR is also maintained along with entire Linux-based operating system, which consists of software components that preserve the same freedom for all software equipment running on the computer and therefore can be passed around to students freely without legal constraints. This system can be also found at www.grifinor.net.

4. CONCLUSIONS

This article identified some impediments of carrying out education programs in geomatics. The use of source code of education was suggested as a possible remedy. But at the same time a lack of specialists who could wisely and seamlessly deploy such new teaching methods was pointed out. Nevertheless, in order to change the situation the article considers the use of source code with open source software as the only possible solution. As an example use of source code for education, the GRIFINOR platform has been introduced in the context as a potential tool to address these problems. The possible uses of the GRIFINOR platform were sketched through the enumeration of project proposals. Everybody is invited to try GRIFINOR and point out its weaknesses and drawbacks for education in practice at www.grifinor.net.

REFERENCES

Free Software Foundation (FSF), 1999, GNU Lesser General Public License, http://www.gnu.org/licenses/lgpl.html#TOC1

J. Kolar, 2007, Managed code interoperability in digital earth technology. *International Symposium On Digital Earth*, electronic publication.

J. Kolar, 2006, On the Road to 3D Geographic Systems: Important Aspects of Global Model-Mapping Technology. *Innovations in 3D Geo Information Systems*, Springer-Verlag, pp. 207–223

E. Kjems and J. Kolar, 2005, From Mapping to Virtual Geography. *In Proceedings of CUPUM 2005*, electronic publication.

The Mapping Science Committee (MSC) and National Research Council (NRC), 2006, *Beyond Mapping: Meeting National Needs Through Enhanced Geographic Information Science*, www.nap.edu/catalog/11687.html

P. M. Ilsoe and J. Kolar (2005), Geo Embedded Navigation. *Geo-information for Disaster Management*, Springer-Verlag, pp 1163-1172.

K. Virrantaus, 2002, The Role of Information Technology in Surveyors Curriculum - The Principle of "Learning One Step More than is Necessary". FIG Commission 2, Malta. www.tkk.fi/Units/Cartography/Fig2/docs

CONTACTS

Ing. Jan Kolář, Ph.D.
Centre for 3DGI, Aalborg University
Fibigestraede 11
9220, Aalborg
Denmark
Tel. +45 96359799
Fax +45 98152444
Email: kolda@3Dgi.dk
Web site: www.3Dgi.dk

Doc. Ing. Jan Kolář, CSc.
Faculty of Science, Charles' University
Albertov 6
128 43 Praha 2
Czech Republic
Tel. + 420 224951408
Fax + 420 221951351
Email: jkolar@natur.cuni.cz
Web site: http://www.natur.cuni.cz/gis/

Experiences with Implementation of the Bologna Agreement in Slovakia

Alojz KOPÁČIK, Slovakia

Key words: Bologna agreement, geodesy education, harmonization

SUMMARY

The Faculty of Civil Engineering of the STU Bratislava was one of the first which started in 1995 the changes in education according the Bologna agreement. In the surveying education were started the new study programmes with new curricula the same year. Next years were step by step changed the surveying programmes at the other faculties and universities in Slovakia. Last one was in this process the TU in Košice, where the mine surveying education was changed to the surveying education according the Bologna agreement in 2005. With this step was finished the innovation process in Slovakia. The experiences about this process will be presented in the paper. Some remarks will be given about the acceptance of surveying bachelors by the practice – government, cadastre service, private sector and the chamber.

1. CONTRIBUTION

The Bolonese challenge declare the creation of the common education space in Europe, with student and education staff mobility and clear system of education levels organised in series. It is shows, that these requirements can fulfil the system of education which is similar to the system of universities in England or in USA, they include the bachelor, master and PhD. study. The economic conditions (possibilities) of more European countries enable the application of the pyramid system with successive reduction the number of students at the higher level of study. The study at the higher level is conditioned by successful graduation at the below level in the same area of interest and successful entrance examination.

In European countries are increase the number of students at universities. We evidence more than 50% increase in many countries. These changes needs the re-structuralisation of university education in whole of brightness. The European university education must react the variability of student population which is coming to universities and commonly must fulfil the requirements of the praxis, to decrease the number of high educated professional staff. The praxis define exactness the education level of the future professional staff. It needs not only theoretically educated research personal, but personal able to creative way deepen the knowledge in their area. In the light of the requirement of the continual professional development (CPD) will be increase the significance of the postgraduate form of higher education (PhD. and another form of study).

2. HARMONISATION PROCESS IN SLOVAKIA

The application of the Bolognese agreement was started in 1995 in Slovakia. Before this time were Geodesy and Cartography programs provided at the Slovak University of Technology (STU) in Bratislava only of 5 year duration. The first changes were made at the Žilina

University in Žilina and the STU Bratislava (Fig.1). After that have ben provided at the STU Bratislava programs at all of education levels (bachelor, master and PhD.), at the ŽU Zilina the bachelor program only. In similar field of study's (mine surveying, geography, space-photogrammetry etc.) are provided this time study programs more than five universities, e.g. at the Komensky University in Bratislava, Technical University in Košice and the Technical University in Zvolen.

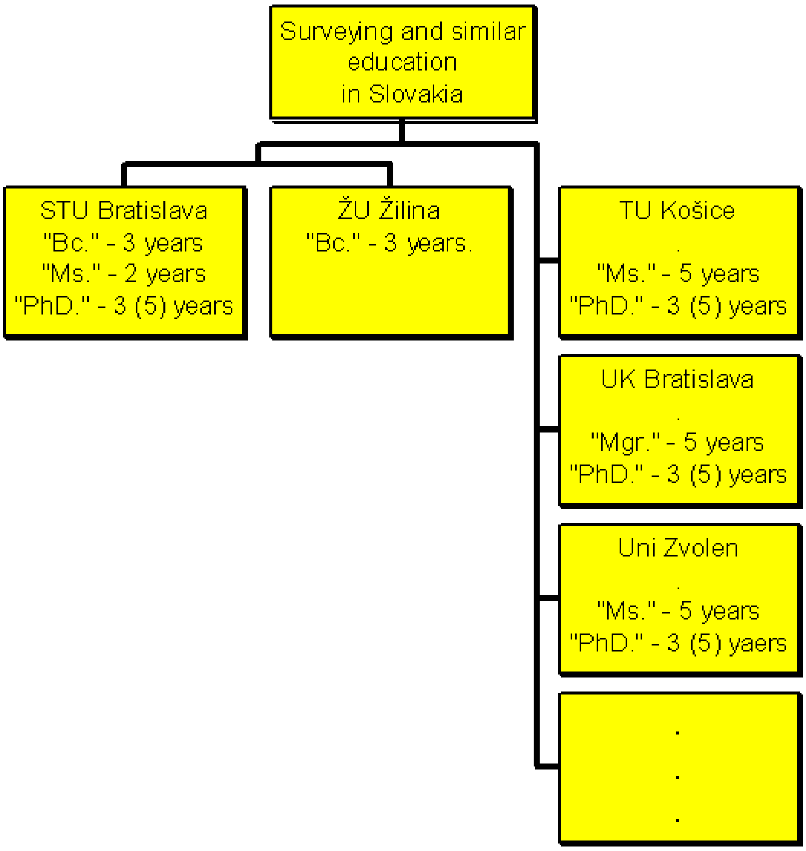


Fig.1 The situation after 1995 in Slovakia

Various study programs, mainly their heterogeneous contents unable the mobility of students, declared by Bolonese challenge. Therefore was decided to finalise the harmonisation of all curricula in Slovakia and consecutive in European region. According this was held the first meeting of the representatives of TU Košice, ŽU Žilina and STU Bratislava in November 2000, where were compared the curricula contents of all participants. The base of this discussion was given by the Geodesy and Cartography curricula of the STU Bratislava, which was accredited in April 2000.

In January 2001 the Ministry of Education had defined the group of specializations in Slovakia. Next was established the working group (WG) of representatives, which should create the basic frame of study programs in Geodesy and Cartography. The WG had defined the list of obligatory and facultative objectives, their credits and minimum hour sizes.

The minimum quantity of the obligatory objectives was defined at level 66% for BSc. study programs and 50% for the MSc. (Dipl.-Ing.) study programs. It was defined firs time the credits and hour sizes for the PhD. study programs, too. For accreditation had prepared study programs in Geodesy and Cartography three universities – STU Bratislava, University of Žilina and the TU Košice (Fig. 2).

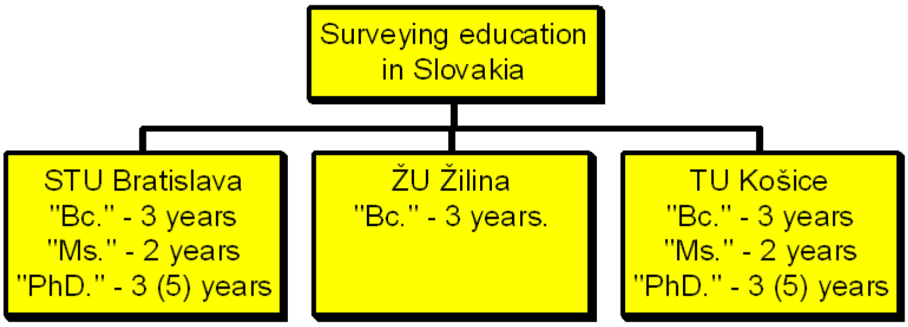


Fig.2 Study programs prepared for accreditation

In January 2004 were finished the accreditation of study programs at University of Žilina and at the STU Bratislava, without the PhD program, accredited in 2005. The accreditation of the study programs at TU Košice was made in April 2005. Outgoing from the prepared materials can be concluded, that through the new programs the harmonized surroundings are build in the field of geodesy higher education in Slovakia. Study programs offered by these three universities after September 2005 are fully harmonized and enable the free mobility of students between these universities in Slovakia.

3. HARMONISATION PROCESS IN EUROPE

At European level was started the harmonisation process in Geodesy and Cartography at the workshop in Delft – November 2000, which was organised by FIG Commission 2 and CLGE. At the workshop was presented the first results of the curricula contents analysis of European universities (CLGE/FIG, 2000).

Very important is the activity in the field of curricula content harmonization that is in process in the frame of the international project of European Faculties of Civil Engineering – EUCEET. The aim of this project is supporting of international student and education staff mobility. The project was started in 1998 with participation of more than 15 faculties. The Faculty of Civil Engineering of the STU Bratislava was participated on the EUCEET project. Our faculty completed the project database by the curricula of tree Slovak Civil Engineering faculties, the faculties of Civil Engineering of the University of Žilina and TU Košice, too. As results of this project is the publication, which included the basic information about faculties and the curricula contents of all provided study programs. In the frame of this project were completed individual publications about the participated faculties, which include all information’s about the faculty, their curricula contents, education staff, libraries and laboratories. In this publication are included the information about accommodation and cultural live in the city and country (EUCEET, 1999). This year was started the third epoch (EUCEET III) of this EU project.

In November 2002 started the EU Socrates Project European Education in Geodetic Engineering, Cartography and Surveying (EEGECS). The project is originally created by geodesy, cartography and surveying institutions, which main objective was to enhance collaboration and co-operation between higher education institutions, which offer these studies, trying to reach the objectives and recommendations of the Bologna and Prague Declaration (EEGECS, 2004). EEGECS has a partnership of 91 institutions from all different European countries. The project involved universities as well as public and private institutions such as associations, city halls, companies, etc.

The aims of this Thematic Network have been structured in six topics and Working Groups (WG's):
- Undergraduate education
- Research, PhD programs
- Continuous education, e-learning and European dimension of studies
- Enterprise-private sector
- Mobility, languages, culture, citizenship, social cohesion, etc.
- Quality assurance.

Base the project aims will be make comparative analysis of study programs, state-of-the-art of the ECTS implementation and Diploma Supplement adoption. The analysis of existing PhD program models was started and including of promotion of joint research programs in different countries. To analyze the needs of private sector the survey of the student applications within Europe was started. It will be create the network of enterprises willing to accept students under practical training.

Each of these international projects prepares information's they will be discussed at universities and EU Commissions. Result of this bright discussion should be the optimal model of study program they should be accepted by universities as standard in university education.

4. CONTINUAL PROFESSIONAL DEVELOPMENT

Connection to permanent technology development is remaining the requirements on professional education of surveyors and cartographers. For the continual professional development (CPD) process are significant the continually organised seminars, conferences and presentation of research results. It will be important to support the information change and communication between professional staff of companies and universities.

Commonly with political changes in 1990 are new professional organisations, chambers and associations formed in Slovakia which conjugate providers of regulated profession. By organisations are exactly defined the requirements for professional development of your members. For example the membership of Chamber of surveyors and cartographers (CSC) is conditioned with short course which is graduated by examination. The course contents are defined by the CSC and the course is provide by Department of Surveying at the STU Bratislava (Kopáčik, 2003).

Besides the mantioned program for CSC are by the Surveying Depertments of the STU Bratislava offered 3 postgraduate programs:
- GPS applications in Geodesy – 40 hours, final certificate

- Modern technologies in engineering surveying – 60 hours + 20 hours training, final certificate
- Methodology and organization of the cadastre – 37 hours + 5 days training, final certificate.

These courses are offered for the graduated students at MSc degree programs in Geodesy and Cartography, only. The certificate given by the university is accepted by all surveying and civil engineering enterprises in Slovakia.

5. QUALITY OF THE HIGHER EDUCATION

Valuation of the quality of higher education in different countries, at different universities is very complicated process. The quality of the higher education in Slovakia is controlled (guaranty) from the site of government by these processes:
- Accreditation of current and new curricula contents
- Evaluation of all faculties by the commission of the Ministry of Education with tree years period.

It is true, that both of those processes are more oriented to fulfill of the quantitative or formal criteria as the qualitative criteria. The result of accreditation is the admission for the faculty to educate and give the title in relevant field of study. The faculty evaluation is the valuation process specially oriented to the categorization of evaluated subjects, to arrange the faculties for determination of the volume of financial support (budget) from the government.

The exact achievement of accreditation criteria require at first fulfill the personal requirements and at the second the material requirements. The quality criteria of the pedagogical process are so repressed (eliminated) by the evaluation process. Another way the faculty evaluation is more oriented to the quality (quality assurance). In this process are the faculty evaluated as complete and not the provided study programs at the faculty.

To this time fully absent the quality assurance of the pedagogical process from the point of view their results – the graduate students. They are missing at this time any information in this process about acceptance the graduate students in praxis, on the international job market. The analysis this art make self the universities or faculties only, to receive arguments for advertising of new students. New information will be received here from companies, the chambers and alumni clubs of universities.

As outgoing point can be accepted for the quality assurance of the education at universities the criteria defined by the European Association for International Education (EAIE). The complete environment for university education higher quality includes (Morgan et all, 1999):
- Design of study programs and curricula contents
- Education, self development and valuation
- Individual work with students (consultations)
- Motivation of students for effort increasing
- Materials sources for self development
- Quality valuation.

The university education higher quality is characteristic with conditions suitable for purchase of the new and permanent knowledge, with climate, which stimulate the students to create and understand the relations between old and new knowledge. Creating conditions they enables creative work of students with aim to apply the new knowledge solving the problems, build model situations to encourage students to achieve their competence give knowledge another, together create environment their encourage students to achieve new and new knowledge.

Heterogeneous materials and basis for quality assurance of education process in separate countries unable the formulation of exact criteria and recommendations. The university environment enables the organization of workshops, provides discussion and periodically sessions of university management and academic staff. The university should provide continual development and self-development of education staff support the horizontal and vertical communication inside the university. The university environment supports student networks, creates connection between research and education, organize seminars, conferences and workshops, student and education staff mobility. The communication between universities and their partners, users of research results and sponsors should be supported.

6. CONCLUSION

The harmonized professional environment, that has undertakes the providing of profession at higher level of quality, is one of the basic requirements of the integration the country to international structure. The participation of our country in non-government organizations must in next years focused to the active attendance in commissions and realization of the resolutions from these sessions in our country, in area the quality assurance, too. Fulfill these aims should:

- Build in quality assurance in all education process and models
- Introduce (establish) these mechanism at universities
- Apply quality management systems developed in another countries for the development of our quality management systems to achieve high quality by surveying education
- Assure fully acceptance and obligatory of CPD system for all surveyors in country
- Support quality management systems in surveying companies and corporations.

The universities should participate on education of management and design of quality management systems. The university staff must be prepared to accelerate and support this process.

REFERENCES

EEGECS – Report 1, 2004: Directorate General for Education and Culture. Printed by UPVT Valencia, Spain. www.top.upvt.es/eegecs

EUCEET, 1999: Faculty of Civil Engineering STU Bratislava. Curricula Contents 2001. EUCEET Project Publication, Bratislava, 2001.

Kopáčik, A. (Eds.), 2003: Work and responsibility of licensed surveyors and cartographers. Slovakia, Bratislava, CSC Publication No.3 (Slovak).

Morgan, P.- Hodgkinson, R.- Enemark, S., 1999: Quality Assurance in Surveying Education. FIG Publication No.19, Denmark, Copenhagen.
CLGE/FIG, 2000: Proceedings of the joint CLGE/FIG seminar „Enhancing Professional Competence of Geodetic Surveyors in Europe“, Netherlands, Delft.

BIOGRAPHICAL NOTES

Kopáčik Alojz, Univ.-Prof. habil., PhD.

Study Geodesy and Cartography SUT Bratislava 1977-82. Doctor study at the Department of Surveying the SUT Bratislava in 1982-85. Senior lecturer 1985-1998, 1998-2004 Assoc. Professor, since 2004 Professor at the Department of Surveying. Lectures from Geodesy for CE, the Underground and Mine Surveying and Engineering Surveying, Measurement systems in engineering surveying and Surveying for Civil Engineering (in English).
Member of the Slovak Chamber of Surveyors and Cartographers. Delegate national for the Com.2 (Education) of the FIG. Member of the board of Geodetski list (Croatia) and the WG's of FIG and IAG, which activity is oriented to implementation of laser technology in geodesy. Research in the filed of TLS applications, automated measuring systems, calibration. Chairman of the TC 89 - Geodesy and cartography (Slovakia), author of 4 ISO standard translations to the Slovak system of standards (STN).

CONTACTS

Prof. hab. Alojz Kopáčik, PhD.
Department of Surveying SUT Bratislava
Radlinského 11
813 68 Bratislava
SLOVAKIA
Tel. +421 2 5927 4559
Fax + 421 2 5296 7027
Email: alojz.kopacik@stuba sk
Web site: www.stuba.sk

Sustainable Curriculum for Geomatics Higher Education

Steve Y. W. LAM, Albert P. C. CHAN, Hong Kong SAR, China

Key words: geomatics, curriculum, higher education, subjects, modules, sustainability

SUMMARY

Sustainable curriculum is currently being advocated in many educational disciplines and professionals in an attempt to 'solve' many of the employment problems confronting higher education. In this contemporary approach, subjects of the geomatics curriculum are being developed for providing double-profession programmes and multiple-disciplinary studies by applying a combination of the outcome-based approach, the social reconstructivist approach and the research-informed approach. Key stages of the curriculum development are explained including aims and objectives, the blended models, the need of swapping cognitive/knowledge-centred and social/student-centred instructional activities, and the use of both formative and summative assessment in the teaching and learning activities.

1. INTRODUCTION

This paper attempts to illuminate how curriculum designers go about the process of developing a sustainable curriculum for geomatics higher education. After 'curriculum' has been defined together with its relationship to pedagogy and assessment, the paper discusses the sustainable approach to the design and planning of the curriculum by combining the traditional outcome-based approach, the social reconstructionist approach and the research-informed approach. The process of curriculum development is then examined from philosophical beliefs and aims of geomatics education to specifying curriculum and instructional objectives, implementing the curriculum and instruction, and assessment of instruction and the curriculum. Because the primary focus of this paper is on curriculum development, less emphasis is given to the subject contents and the instructional process. However, such contents and instructional process are illustrated in (for example, Lam, 2006a).

Geomatics higher education encompasses the process of curriculum, pedagogy and assessment supported by and integrated with the values, beliefs and culture of society (Berstein, 1971). Berstein (1971) defines curriculum as what counts as valid knowledge. Pedagogy is the instructional process by which knowledge is delivered and assessment indicates the achievement of valid learning outcomes from acquiring that knowledge. Putting into the context of geomatics education, their aims and relationship can be determined by answering the following questions:

- What is an educated land surveyor or geomatics engineer?
- How to design and plan a sustainable curriculum in order to fulfill societal demands?
- What should learners learn?
- How should the curriculum be learned, taught and assessed?

2. A CRITICAL REVIEW ON THE DESIGN AND PLANNING OF CURRICULUM

What is an educated surveyor? Through the processes of schooling, independent learning and professional practice, successfully educated surveyors are knowledgeable lifelong learners, physically and mentally fit for the jobs and for economic self-sufficiency, and respecting to the rule of law. Major orientations to the design and planning of a curriculum can be grouped into the following approaches: outcome-based approach (Tyler, 1949), the social reconstructionist approach (Eisner and Vallance, 1974), research-informed approach (Corey, 1953; McKernan, 1996; Senaratne et al., 2006), and sustainable approach by combining appropriately the aforementioned ones (Eisner and Vallance, 1974; Skilbeck, 1984).

In the outcome-based approach, the curriculum encompasses aims and objectives, expected learning outcomes, curriculum content, organization of teaching and assessment, and continual evaluation (Tyler, 1949; Wheeler, 1967). The curriuclum emphasizes applications, core/basic skills, background/pre-requiiste knolwedge, and independent self-study (Gagne, 1974, 1985). Its main contribution is the improvement of teaching and learning, organising sequence, and assessment of learners’ outcomes. Its main weaknesses, however, are probably the negligence of: school and resources management; changes of school organization, teacher character and community values; changes of learning outcomes in cognitive domain (e.g., changes in learners’ thinking), affective domain (e.g., changes in levels of values and attitudes) and psychomotor domain (e.g., changes in perceptive abilities of learners). In the social reconstructionist approach, the curriuclum emphasizes social interests and individual needs. It is difficult to apply among vast amount of learners in the present role of education and school but possible in workplace learning and in learning organizations. In the research-informed approach, curriculum contents and practices are continually updated and improved by action research (McKernan, 1996) (see Figure 1).

In the sustainable or ecological approach, knowledge and practice are first agreed by members of society under social reconstructionist model for environmental protection, ecological coherence with the natural systems and for fulfilling the needs of society or particular community. Wheeler (1967)’s outcome-based model is then applied in the design and planning of the curriculum by having the following key cyclical stages: (1) aims and objetcives (learning outcomes) determined from the needs of society, needs and prior knowledge of students and needs of teachers; (2) selection of learning experiences; (3) selection of curriuclum content; (4) organization of teaching and assessment; and (5) curriculum evaluation. Continual improvement of the curriculum will be undertaken by applying the reserach-informed approach as shown in Figure 1.

This approach has less emphasis on individuals’ needs and has the difficulty of understanding the relationships between the subjects and integrating their knowledge to solve real-world problems. The latter can be conquered by integrating the curriculum in either multidisciplinary approach in teaching a thematic unit which relates individual subjects to a singular topic without making direct connections across the subject areas, or connecting the subject areas and relating them to real-life problems in learning and teaching (Fogarty, 1991; Beane, 1997). Thereafter, knowledge are constructed through problem-based learning or workplace learning so that learners can understand and integrate knowledge from different perspectives and different subjects in an active environment. The overall quality of the curriculum can be evaluated under the categories of staffing qualification, learning environment and accommodation, students' access to equipment, teaching and learning quality, standards achieved by students (including employment rate), and management and quality control (Ashworth and Harvey, 1994).

3. WHAT SHOULD LEARNERS LEARN?

Valid knolwedge is what learners should learn. To be valid, the knowledge associated with the geomatics curriculum must be expert knowledge or justified to have high status. Subjects and modules of a geomatics curriculum for higher education is illustrated in Table 1. Period of study for each module is one semester or 14 weeks, with a total of minimum 42 hours of lectures and tutorials for each core module. Core subjects with two modules are having ordinary and higher levels. The ordinary-level core modules can become minor subjects serving other departments. The programme would be accredited by professional organizations, both local and overseas. So that, on completion of the programme of study and professional training, students are qualified for the award of Professional Land Surveyor Licence and/or Professional Information Engineer Licence. Along with the double-profession degree strategy, the geomatics programme is heavily loaded with subjects of computing science and information technology (IT) so that graduates can achieve a second Bachelor Degree (BSc in Computing/IT) in one year of further study. More undergraduate degree programmes for raising multi-disciplinary professionals are under collaborative devlopment with other departments, for exmaple, Departments of Computing, Logistics Management and Geography wthin the same university or with other universities. The Department of Land Surveying and Geo-informatics of Hong Kong Polytechnic University found that the launching of these two value-added strategies in Year 2005/06 Admission resulted in increasing number of applicants and that better quality of high school graduates were admitted into the Department. We also foresee more emplyment opporutnities for our future graduates in areas of land surveying, geo-IT, GIS, real estate and government services (e.g., security forces).

4. HOW SHOULD THE CURRICULUM BE LEARNED, TAUGHT AND ASSESSED?

What are the learning experiences? Blended learning environment is most effective for supporting experiential and situated learning by combining different disciplinary models with different media to create optimum teaching and learning programme (Bersin, 2004). The blended teaching and learning models recommended by Bersin (2004) are e-learning blended with media or events, instructor-led programme blended with self-study and e-learning, on-the-job training, and use of simulation systems. Effective learning is also found with directed instructional method in the situation where revision or re-teaching of the topics is needed by swapping the cognitive/knowledge-centred model and social/student-centred model back and forth as shown in Figure 2. Formative or continuous assessment helps to communicate lecturer's expectations and standards to students and to improve students' knowledge level by providing them with answers of the assessment. At the end of the session, summative assessment in the form of written examination is organized to assess the effect of the completed programme and compare the performance of students for selecting successful learners to receive awards, scholarships and advanced level of studies. Teacher performance can be assessed by the overall student performance, student feedback questionnaire, teaching portfolio, in-class peer evaluation by colleagues or academic advisors, and the teaching and learning committee. Further evaluation of the curriculum is anticipated in the form of research-informed approach in which assessment is related to the specific measurable learner, process or outcome objectives of the curriculum.

5. CONCLUSIONS AND FURTHER DEVELOPMENT

This paper has presented the development of a sustainable curriculum for geomatics higher education by applying the two value-added strategies of providing double-profession programme and multiple-disciplinary studies so that geomatics graduates become multi-disciplinary professionals and have better employment opportunities in their careers. Moreover, geomatics education should not be bounded inside educational institutions only but extended to informal and non-formal education to support lifelong learning under the models of workplace learning, learning organizations, knowledge management, organizational learning, communities of practice, social learning systems and the learning cities (Reeve et al., 2002, p. 1). Future development of the curriculum will continue with emphases on multi-skilling, problem-solving skills and management and social skills required of individuals. Curriculum research on geomatics is on-going, and the authors would appreciate receiving comments from readers who might have on any aspects of geomatics education.

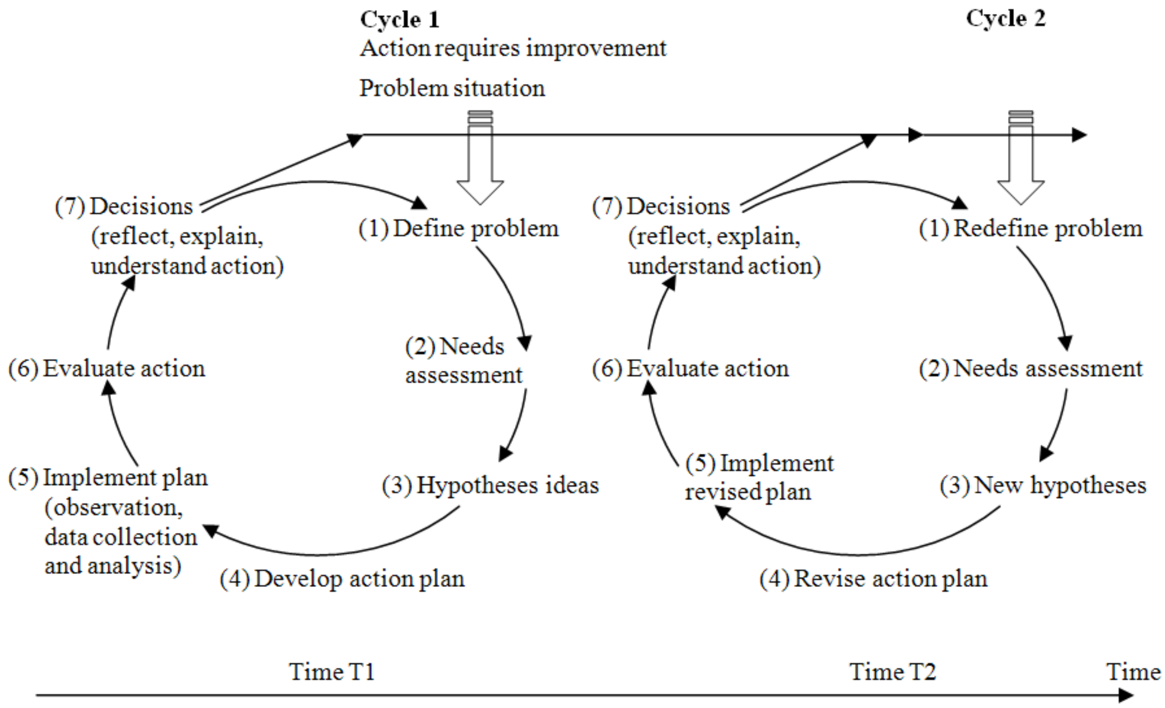


Fig. 1: The spiral-cyclical model of curriculum research. Modified from (McKernan, 1996, Fig. 1.6)

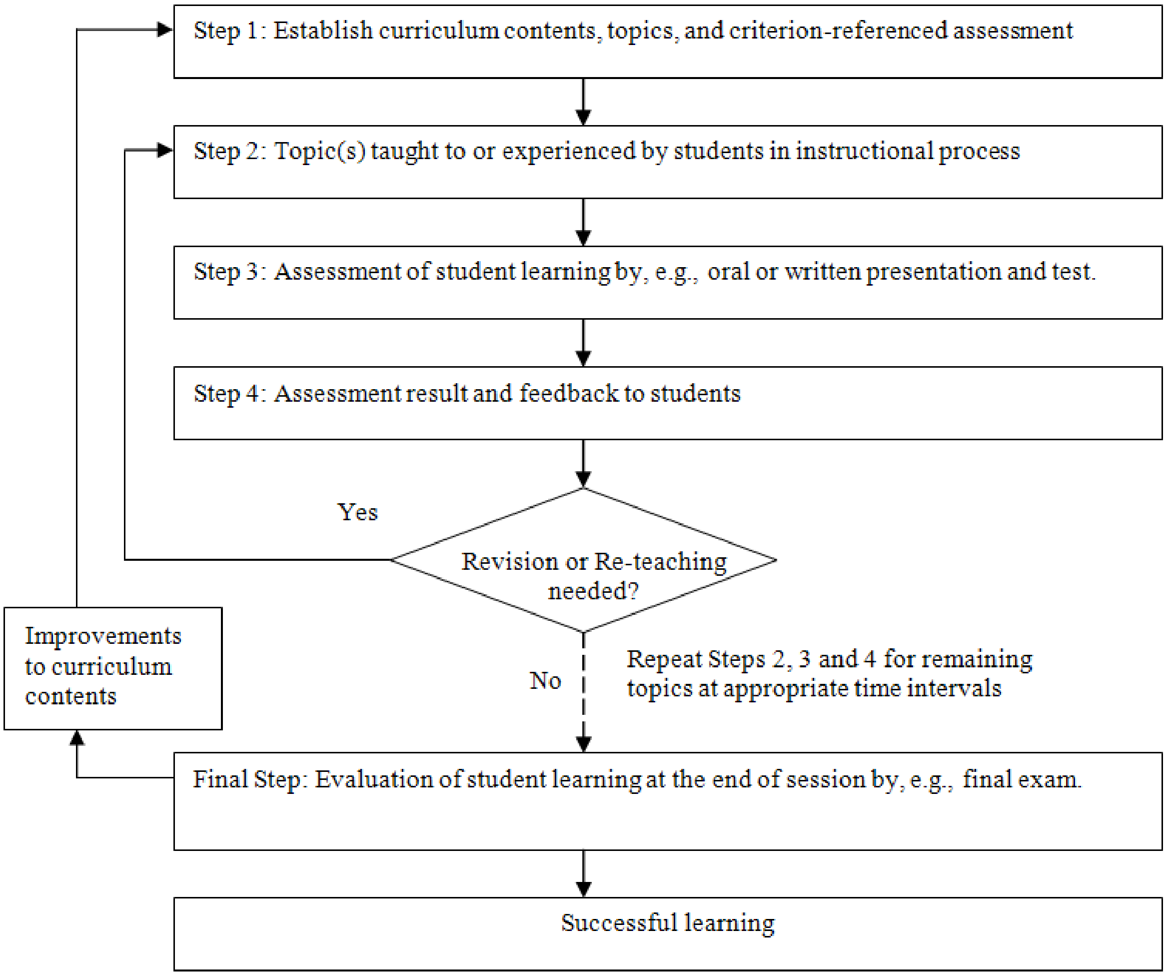


Fig. 2: Formative and summative assessment that supports a teaching and learning process (Lam, 2006b, Fig.1).

Table 1: Subjects and modules of BEng/BSc programme in Geomatics

Major subjects	No. of Modules
Geodesy and Global Navigation Satellite Systems (GNSS)	2
Photogrammetry	2
Remote Sensing and Image Analysis	2
Engineering Surveying	2
Cadastre, Land Registration Information Systems (LRIS) and Land Administration	2
Spatial Information Management and Geo-Information Technology (Geo-IT)	1
Applications of Geographic Information Systems (GIS)	1
Cartography and Map Production	1
Hydrographic Surveying and Hydrographic Information Systems (HIS)	1
Statistical and Adjustment Analyses for Geomatics	1
Geomatics Business Management	1
Geomatics Research Methodology and Dissertation	1
Survey Camps/Projects (Control Network, GIS Mapping, Photogrammetry, Hydrography, Boundary, and Metrology/Construction)	2
Sub-total:	19
Minor Subjects	
Advanced Engineering Mathematics	2
Computer Programming and Data Structures for Engineers	2
Information Systems and Internet Technology	1
Construction Technology and Management	1
Environmental Engineering Systems	1
Property Appraisal, Development and Finance	1
Urban Economics	1
Real Estate and Facilities Management	1
Second Language	1
Subjects of humanities and introductory knowledge of other professions/disciplines	2
Sub-total:	13
Total Modules	32

REFERENCES

Ashworth, A. and Harvey, R. (1994), *Assessing Quality in Further and Higher Education,* London: Jessica Kingsley Publishers.

Beane, J. (1997), *Curriculum Integration: Designing the Core of Democratic Education*, New York: Teachers College Press.

Bernstein, B. (1971) ‘On the classification and framing of educational knowledge’ in Young, M. F. (ed.) *Knowledge and Control*, London: Collier-Macmillan.

Bersin, J. (2004), *The Blended Learning Book: Best Practices, Proven Methodologies, and Lessons Learned*, San Francisco: Pfeiffer.

Corey, S. M. (1953), *Action Research to Improve School Practice*, New York: Teachers College Press.

Eisner, E. and Vallance, E. (Eds., 1974), *Conflicting Conceptions of Curriculum*, California: McCutchan Publishing Corporation.

Fogarty, R. (1991), *The Mindful School: How to Integrate the Curricula*, Illinois: Skylight Publishing, Inc.

Gagne, R. (1974), 'Educational Technology as Technique', in Eisner, E. and Vallance, E. (eds.), *Conflicting Conceptions of Curriculum*, pp. 50-63, California: McCutchan Publishing Corporation.

Gagne, R. (1985), *The Condition of Learning and Theory of Instruction*, 4th ed., New York: Holt, Rinehart and Winston.

Lam, S. (2006a), Business Management for Geomatics Education, *Proceedings*, XXIII International FIG Congress: Shaping the Change, 8-13 October 2006, Munich.

Lam, S. (2006b), Development of Business Management Curriculum for Geomatics Education, *Geomatica*, Vol. 60, N0. 4, pp. 369-372.

McKernan, J. (1996), *Curriculum Action Research: a Handbook of Methods and Resources for the Reflective Practitioner*, 2nd ed., London: Kogan Page.

Reeve, F., Cartwright, M. and Edwards, R. (Eds., 2002), *Supporting Lifelong Learning Volume 2: Organizing Learning*, London and New York: RoutledgeFalmer and The Open University of UK.

Senaratne, S., Amaratunga, D., Baldry, D., Kagioglou, M. and Aouad, G. (2006), Integrating Research and Teaching in Higher Education: Conceptual Issues, *Proceedings,* International Conference on Building Education and Research 2006: Construction Sustainability and Innovation, 10-13 April, Hong Kong.

Skilbeck, M. (1984), *School-Based Curriculum Development*, London: Harper and Row Publishers.

Tyler, R. (1949), *Basic Principles of Curriculum and Instruction*, Chicago: University of Chicago Press.

Wheeler, D. (1967), *Curriculum Process*, London: University of London Press.

BIOGRAPHICAL NOTES

Steve Lam, BTech, BA, MSc, MPhil, FICE, FInstCES, MRICS, MCIOB, worked as construction engineer and Canada Lands Surveyor (CLS) in construction, land boundary and GIS projects in several countries from 1971 to 1997. Since then, he has been a Lecturer in the Department of Land Surveying and Geo-Informatics at The Hong Kong Polytechnic University.
Ir. Professor Albert Chan, MSc, PhD, FCIOB, FHKIE, MIEAust, MRICS, RPE, is a Chartered Builder, Engineer, Project Manager and Surveyor by profession, currently the

Associate Head of the Department of Building and Real Estate at the Hong Kong Polytechnic University. He is also an Adjunct Professor of the University of South Australia, and Queensland University of Technology, Australia, and a Founding Director of the Construction Industry Institute, Hong Kong.

CONTACTS

Mr. Steve Y. W. Lam
The Hong Kong Polytechnic University
Department of Land Surveying and Geo-Informatics
Hung Hom, Kowloon,
Hong Kong SAR
People’s Republic of China
Tel. + (852) 2766 5964
Fax + (852) 2330 2994
Email: LSLAMS@polyu.edu.hk

Some Experiences of the Bologna Process in Geodesy and Geoinformatics Undergraduate Study in Croatia

Miljenko LAPAINE, Zdravko KAPOVIĆ, Stanislav FRANGEŠ, Croatia

Key words: Bologna process, geodesy, geoinformatics, undergraduate study, Croatia

SUMMARY

The introduction of the paper features a brief presentation of the Faculty of Geodesy of the University of Zagreb as the only high education institution in Croatia at which one can study geodesy and geoinformatics at undergraduate, graduate or postgraduate levels.

The focus of the article is the description of undergraduate study of geodesy and geoinformatics at the Faculty of Geodesy of the University of Zagreb. This study started according to the new curriculum in academic year 2005/06. The paper notes first experiences of applying the Bologna process on first two generations of students. Some characteristics of this study are: a large number of students, simultaneous introduction of academic institutions information system, beginning of e-education, absence of Study Regulations, execution of continuous assessment of students' knowledge and skills, partial or complete exam removal for some students, financial problems, etc.

Besides the student survey, which is being carried out in the same way for the whole University, results of surveys by the Ministry of Science, Education and Sport were interpreted, as well as the survey by the vice-rector for education of the University and the survey that was recently conducted independently by students of the Faculty of Geodesy.

1. INTRODUCTION

Croatia has a rather long tradition of higher education in surveying and geodesy. The textbook written by Martin Sabolović *Exercitationes Gaeodeticae* was printed in 1775 in Varaždin. The first diplomas young graduates were presented certifying they passed all necessary exams to acquire the academic degree and authorizations to act as surveyors were handed in 1811.

After the Royal Forestry Academy had been founded in Zagreb in 1898, geodesy was taught there among other technical subjects. The Geodetic Course (Geodetski tečaj), whose 'learning basis' was completely identical to the curricula of the geodetic studies at the high schools in Prague and Vienna, was included in the Forestry Academy program. At the moment of the foundation of the Technical High School in Zagreb in 1919, the Geodetic Course moved to a newly founded school, and then its academic status was defined.

It was in 1962, when the Faculty of Geodesy of the University of Zagreb was founded. Since the, the Faculty of Geodesy has organized the university undergraduate studies for acquiring high level education and postgraduate studies for acquainting the MSc and PhD degrees in the field of geodesy. The university undergraduate studies lasted for nine semesters, including the creation of diploma thesis. These nine semesters are actually just a theoretical value because the average duration of study was almost seven years.

The university curricula were altered several times during the last century. The last 'Bologna' change of curricula at the Faculty of Geodesy, but also at almost all faculties in Croatia, was done in 2005.

2. THE NEW BACHELOR STUDY OF GEODESY AND GEOINFORMATICS IN ZAGREB

The basic elements of the latest reform are: introducing law and management into the curriculum, considerable reduction of the number of classes of some traditional subjects, introducing numerous new professional subjects related to informatics, a filed with increasing importance. In order to successfully execute the new curriculum, of importance are decisions by the Faculty Council, according to which the professors are required to prepare their lectures for the new subjects in digital form and make them available to students via web pages.

The new Bachelor and Masters curricula in Geodesy and Geoinformatics at the University of Zagreb, Faculty of Geodesy were approved by the Ministry of science, education and sports, and the Bachelor studies started in 2005/06. Before coming to the new curricula, it was necessary to make a decision concerning the new title of study programs and define new educational profiles for bachelors and masters.

Scientific work and its connection with the educational process have affected the consistent introduction of new concepts in education. Due to increasing application of new technologies, the study title itself was also changed, from Geodesy to Geodesy and Geoinformatics, which is also going to help change the image and increase the affirmation of the profession. In that context, this change was just a logical continuation, which is supplemented by adapting the study to the Bologna Process.

The new Bachelor studies in Zagreb last three years, that is six semesters, and a student obtains 60 ECTS points for each academic year in which he or she meets all regulated conditions. By finishing the undergraduate studies, one acquires 180 points and the title bachelor or baccalaureus in geodesy and geoinformatics, and competences for executing all works of today's professionals in surveying, geodesy, geoinformatics or geomatics, with a lower level of responsibility than graduates, that is masters. The Bachelor studies end with a final exam for those students who do not wish to continue to study.

2.1 Some Statistics

Graduate engineers in geodesy have never had any difficulties in getting employed in Croatia, and the present situation in the work market indicates that each of 40 annually graduating engineers finds an adequate job immediately. Private companies and the public sector grant scholarships and stimulate students in other ways in order to provide high-quality experts for them.

The first semester of the academic year 2005/06 featured the first education according to the new Bachelor program Geodesy and Geoinformatics, adapted to the Bologna Process. However, one should take into consideration that this semester is not going to be representative by its results, since the number of students enrolled in the first academic year (224) was almost double the number of students enrolled in the academic year 2004/05 (115 students). This was because the enrolment quota was increased (from 115 to 135 students), the possibility pf enrolment according to the special laws (26 students), and the fact that students who failed the 1st year were directed to studying according to the new Bologna Process (63 students). It was impossible to execute parallel education for the first year students of old and new programs. The great number of students made difficult the execution of continuous student's knowledge evaluation, and mentor work with smaller groups of students was made completely impossible due to lack of professors and assistants.

There were 263 candidates at the classification procedure in the academic year 2006/07. A total of 144 new students enrolled, 90 out of which had their study financed by the Ministry of Science, Education and Sport, 25 enrolled for personal needs and 29 according to the Law about Rights of Croatian Defenders from the Homeland War.

According to the new Bachelor and Masters curricula of Geodesy and Geoinformatics, the optimal number of students able to enrol with respects to space, equipment and the staff number at the Faculty of Geodesy, University of Zagreb is about 150. However, looking in advance at the possibility of employment and needs, the Faculty plans to enrol 115 new students in the next academic year, 2007/08.

The main characteristics of this study in Zagreb are: a large number of students, simultaneous introduction of Academic Institutions Information System, beginning of e-education, absence of Study Regulations, execution of continuous assessment of students' knowledge and skills, partial or complete exam removal for some students, financial problems, etc.

One of the largest unknowns in applying the Bologna Process is the financing of study programs. Until now, the financing of faculties was done according to the number of students, or the number of education staff. In the future, programs are going to be financed, while the faculties are going to have a great deal of autonomy.

According to the first research, the new programs make the studies 30% more expensive. Since the Ministry of Science, Education and Sport of the Republic of Croatia has not allotted the required resources for covering material expenses of studying at the right time in the past, it is not known how it is going to work out in the future.

3. SURVEYS ABOUT THE IMPLEMENTATION OF THE BOLOGNA PROCESS AT THE UNIVERSITY OF ZAGREB

Besides the student survey, which is being carried out in the same way for the whole University, results of surveys by the Ministry of Science, Education and Sport will be presented here, as well as the survey by the vice-rector for education of the University and the survey that was recently conducted independently by students of the Faculty of Geodesy.

On the basis of meeting with vice-rector for education, Prof. Dr. Vjekoslav Jerolimov, on the basis of numerous meetings with vice-deans for education of other faculties, mostly technical and mostly with vice-deans for education of the Faculty of Architecture and the Faculty of Civil Engineering, the basic conclusion is that the execution of the Bologna process is proceeding as planned, although with numerous problems, obscurities and issues solved on the run, as minister of science, education and sport Dr. Dragan Primorac suggested.

Within that context, it was suggested that the first year of applying the Bologna process should be used to verify various forms, models, ways of carrying out instruction, etc. with mandatory continuous knowledge evaluation with the possibility to have the students not take a part of an exam or an entire exam where possible.

Former discoveries in applying the Bologna Process at the University can be viewed through several researches and analyses. One of them was conducted by the Ministry by means of survey «Evaluation of the Success of Executing Study Programs Carried out According to the Bologna Model». Questions were like:

- Are the courses well thought-out, arranged and graded?
- Can the students choose between a sufficient number of optional courses at the faculty?
- Can the students choose between a sufficient number of optional courses at other faculties?
- Evaluation of student mobility
- Are the criteria of acquiring ECTS points clear?
- Evaluation of exam passing after the winter exam period?
- Does the high-education institution possess enough lecture rooms, gymnasiums and laboratories?
- Evaluation of the number of scientific-educational staff needed for normal execution of education
- Evaluation of the number of assistant staff needed for normal execution of education
- Evaluation of the load of lectures, seminars and exercises on students
- Evaluation of the equipment of high-education institution for execution of instruction
- Evaluation of informatics equipment, etc.

Overall success grade of executing study programs according to the Bologna model is very good (4).

Vice-rector Jerolimov requested that faculties comment on the new study model and suggestions for its improvement. We stressed these facts: too many students, not enough professors and collaborators, not enough lecture rooms, computer rooms and laboratories. Despite these problems, the results of the first semester of the academic year 2005/06 are satisfactory according to our assessment. On the basis of our and other comments related to the new study model, vice-rector Jerolimov obtained the average grade of little over sufficient (2).

It can be seen from this that there are significant disproportions in the overall success grade and what their magnitude is in certain elements.

Knowing the fact that it is not easy to realize new ideas and change the foundations of the program in just a year and expect everything will work out flawlessly, the question is who is going to be affected. Namely, the adequate conditions for students are not secured, and the criteria have remained the same.

In order to enrol the second year, a student needs to obtain all 60 ECTS points. Only 24 students achieved that, which is about 10%.

In order to gain better insight into the quality of instruction of particular courses of the bachelor study Geodesy and Geoinformatics, students have independently conducted a survey among the first generation of Bologna students. The survey was completed by 120 students that graded certain elements with grades 1-5: assistants, professors, organisation and difficulty of all courses from the first year, including optional courses they attended. The results of the survey were represented by diagrams, and finally an average for each course was formed from assistants, professors and organisations, excluding difficulty because it isn't related to the quality of a particular course. When grading the difficulty of a course, 1 meant easy, 5 difficult (see Fig.1-5, adopted from Božić and Delač 2006).

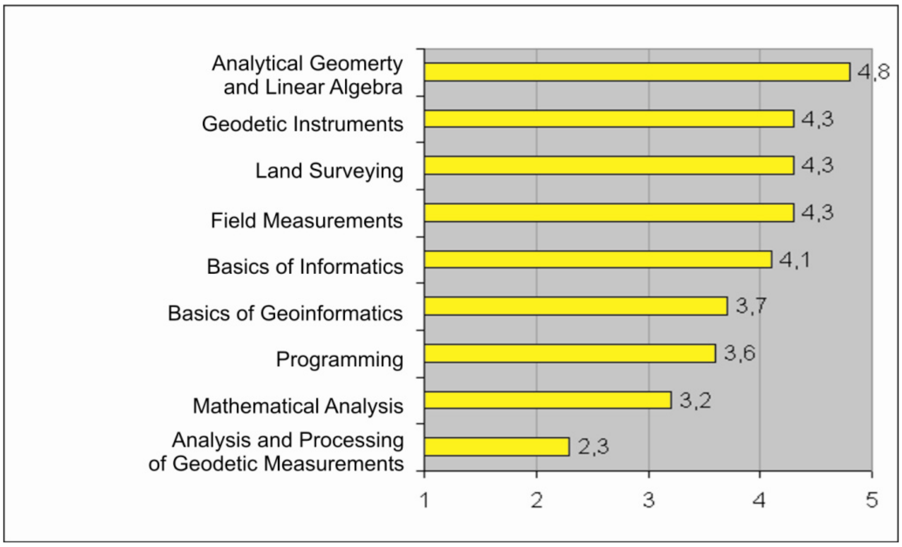


Fig. 1: Assistants versus courses

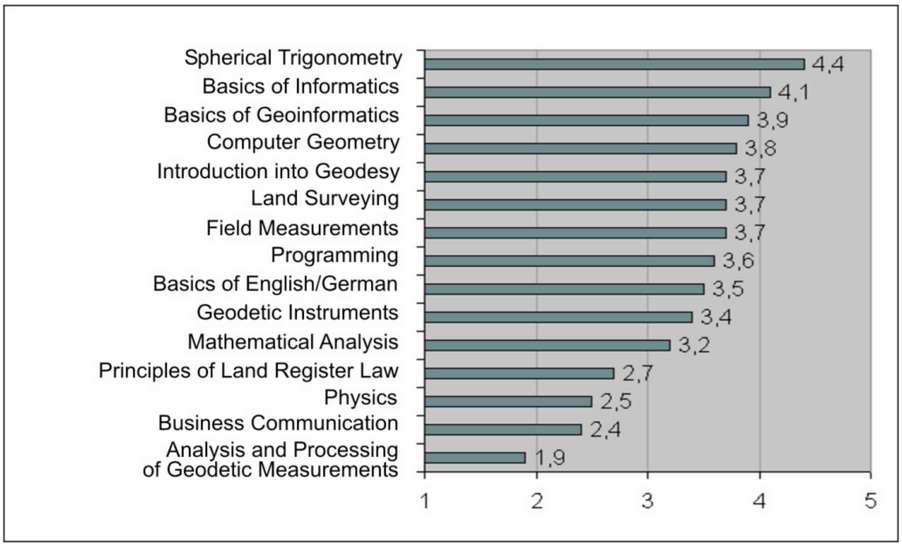


Fig. 2: Teachers versus courses

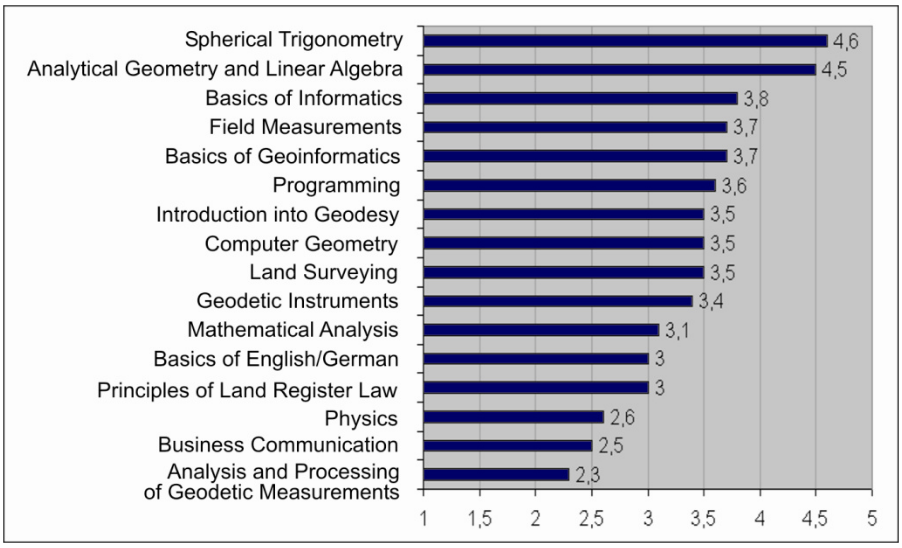


Fig. 3: Organisational aspects versus courses

Besides the overall deficiency in execution, some specific problems and obvious omissions in planning the curriculum that contributed to bad results have to be addressed. The most problematic course from the first year, which can be seen from the student survey (Božić, Delač 2006), seems to be *Geodetic Measurement Analysis and Processing*, a course which encompasses and summarizes matter from earlier courses *Error Theory and Adjustment Calculation 1* and *2*. The problem is the fact that only 35 out of 224 students passed the course's exam, which raises the issue: what or who the problem is? According to students, the problem is primarily that the course is completely inadequate for the first year, because of insufficient knowledge of mathematics and the fact that students have to struggle with measurement adjustments the likes of which they have never encountered before, neither in practice, nor in theory. Furthermore, due to lack of assistants, only two instead of three hours (as in the curriculum) of exercises were held each week. When one takes into consideration the fact that a student needs his or her exam to be 100% correct to pass and even in that case may sometimes not pass, the answer to the question why only 15% percent of the students passed it becomes quite obvious.

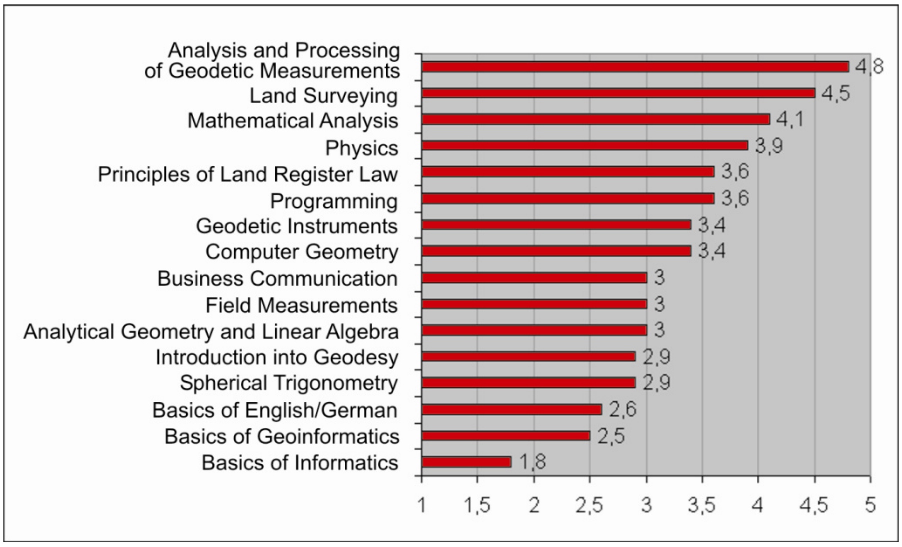


Fig. 4: Difficulty versus courses

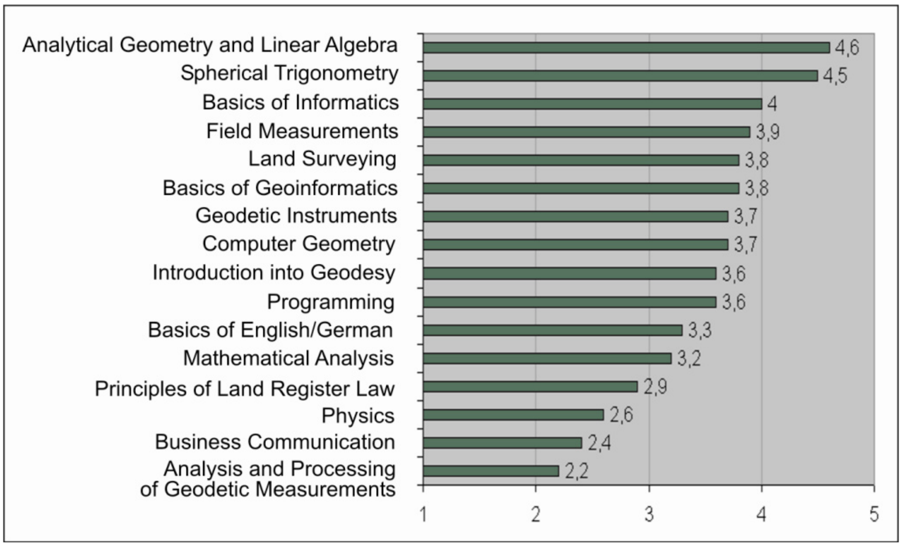


Fig. 5: Average grade versus courses

It is also important to stress that drastic reduction of matter from previous *Mathematics 1, 2* and *3* and in a way putting mathematics into the first semester led to difficulties for students in the course *Differential Geometry* in the third semester because it appears that students do not possess enough knowledge of differential calculation. These are only some of the problems perceived in the student survey carried out at the Faculty of Geodesy in Zagreb.

Time will show how the instruction is going to be conducted in the future and which measures are going to be taken in order to improve efficiency of the study.

4. INSTEAD OF CONCLUSIONS

It appears that executing instruction according to the Bologna Process is more similar to elementary and high school instruction than the way most of us studied and later carried out instruction. On the other hand, the high school way of instruction, ending with a national exam and national tests which started in 2005, with earlier announcements that success in elementary and high schools should not be graded, are going to lead to high education way of instruction, sooner or later. Consequences and results of such, as it seems, change of way of instruction, are not going to be seen before 3, 4, 5 or even more years, when first students studying according to new programs graduate.

REFERENCES

Božić, B., Delač, I. (2006): Godina dana bolonjskog procesa na Geodetskom fakultetu, Ekscentar, List studenata Geodetskog fakulteta, No. 8, 114-119.

Kapović, Z., Frangeš, S., Medak, D. (2006): Bolonjski proces na Geodetskom fakultetu Sveučilišta u Zagrebu, Geodetski list; No. 1, pp 29-50.

Lapaine, M., Kapović, Z., Frangeš, S. (2006): New University Curricula of Geodesy and Geoinformatics in Croatia, on CD Proc. XXIII International FIG Congress, October 8-13, 2006, Munich, www.fig.net/pub/fig2006/papers/ts34/ts34_04_lapaine_etal%20_0599.pdf.

Lapaine, M. (2007): Geomatics Education in Croatia, GIM International, Vol. 21, Issue 3.

BIOGRAPHICAL NOTES

Miljenko Lapaine was born in Zagreb in 1952. He studied mathematics and graduated from the Faculty of Science, University of Zagreb, in the field of theoretical mathematics in 1976. He finished the postgraduate studies of geodesy, the field of cartography in 1991 at the Faculty of Geodesy in Zagreb by defending his Master thesis *A Modern Approach to Map Projections*. He obtained his PhD at the same Faculty in 1996 with a dissertation *Mapping in the Theory of Map Projections*. He has been a full professor since 2003. He published more than 550 papers, several textbooks and monographs. He is a full member of the Croatian Academy of Engineering, a founder and a vice-president of the Croatian Cartographic Society and the chief editor of the *Cartography and Geoinformation* journal.

Zdravko Kapović was born in Opuzen in 1948. He graduated from the Faculty of Geodesy, University of Zagreb in 1974. He received his Master's degree in 1984, and his PhD in 1993 in the field of Engineering Geodesy. He has been a full professor since 2002. His subjects are Engineering Geodesy, Movements and Deformations, Organization of Geodetic Works and Geodesy in Environment Protection. He published about 70 papers. He led scientific-professional expertises of geodetic surveys in testing and evaluation of constructions for more than 500 objects. His scientific-professional activities include geodetic works in civil engineering, measurement of movements and deformations of objects, and geodesy in environment protection. He has been the dean of the Faculty of Geodesy in two mandates: 2003-2005 and 2005-2007. He was the president of the Croatian Geodetic Society from 1996 to 2004.

Stanislav Frangeš graduated from the Faculty of Geodesy, University of Zagreb in 1984, obtained his Master's degree in 1993 by defending his Master's thesis *Differentiation of Objects on Maps with Area Symbols*, and his PhD by defending his doctoral thesis *Map Graphics in Digital Cartography*. His subjects are Geodetic Drawing, General Cartography, Topographic Mapping, Thematic Mapping, Map Reproduction and Map Visualisation. He published several course materials and about 20 cartographic representations. He was awarded for excellence in cartography at the International Cartographic Exhibition in Ottawa in 1999. He was the head of the Institute for Cartography and the chief editor of Geodetski list. He is the vice-dean for education at the Faculty of Geodesy, University of Zagreb.

CONTACTS

Prof. Dr. Miljenko Lapaine, Prof. Dr. Zdravko Kapović, Prof. Dr. Stanislav Frangeš
University of Zagreb, Faculty of Geodesy
Kačićeva 26
10000 Zagreb
CROATIA
Tel. +385 1 46 39 273
Fax +385 1 48 28 081
Email: mlapaine@geof.hr
Web site: www.geof.hr

How to Enhance the Interest for Surveying Studies

Reinfried MANSBERGER, Gert STEINKELLNER, Austria

Key words: surveying education, professional education, occupational image, marketing of surveying studies

SUMMARY

At the beginning, the paper gives a short overview on the present situation about the interest on surveying studies in Austria. In the second part, the authors scrutinize the paradoxes, that due to a huge number of new surveying technologies, due to new markets for surveyors, and due to the promoted good job perspectives the number of surveying students is decreasing or at least stagnating. Finally, strategies for improving the interest on surveying studies are outlined.

1. INTRODUCTION

"*Official Warning: Don't study Surveying*" was the subject of an official letter sent by the president of the Austrian Federal Office of Metrology and Surveying (BEV), Alfred Gromann, to the rectors of the Universities of Technology in Vienna and Graz. In this letter, published in the journal of the Austrian Association of Surveying, Gromann pointed out the discrepancy between the increasing number of students and the limitation of available jobs and he requested the universities to inform incoming students about the dismal situation of employment in the field of surveying (Gromann, 1932).

In the last 75 years a lot of things changed. During the last decades in Austria, Germany and Switzerland the number of students in surveying was decreasing or stagnating - contrary to the general trend of growing totals of students registered at Austrian, German or Swiss universities.

Institutions providing academic surveying education are starting to promote very actively the surveying studies. Messages, like "*Job possibilities of graduates in surveying are nowadays good to excellent*" (Geofuture, 2007), "*Graduates of surveying are objects of desire*" (Geoinfo, 2007), "*Specialist with international highly recognised academic qualification*" (Geoinfo, 2007), or "*Nearly all students of surveying will find a well-paid job after having finished their studies*" (Geoinfo, 2007) were announced to the public. Nevertheless, due all these public relation activities, due to the good job perspectives, and due to all efforts to improve curricula and teaching methods a stagnation of students in surveying still exists. In some countries of Central Europe, universities have to cancel study courses in surveying due to the low number of students. Nowadays the introduction of new management at the Austrian universities and its exceeding of measuring the need of a specific study courses by the number of students endangers the continued existence of several study courses at academic education institutions in Austria (Liessmann, 2006).

2. STATE OF THE ART

The profession of a surveyor has dramatically changed within the last decades. On the one hand new and easy-to-handle surveying instruments and technologies were introduced and opened classical land surveying tasks to other professions. On the other hand new chances and markets were offered for the surveying profession.

In Central Europe and especially in Austria the field of activities for surveyors is very narrow: The Austrian surveying education has not integrated the professional sub-areas *urban and rural planning, land valuation* and *real estate management* into their study programs with the consequence that also the professional activities in these fields are normally not part in the portfolio of an Austrian surveyor.

Despite the above-mentioned limitations in the field of professional employment, the demand on graduates of surveying studies is still high in Austria. Knowing that an essential driver for selecting a specific study is the employability, it is not reproducible, that the interest in surveying studies is decreasing or at least stagnating.

The educational institutions are endeavoured to meet the challenges of the surveying profession by promoting the surveying studies, by advertising the career prospects, by modernizing the curricula, and by adapting curricula to the needs of the Bologna Declaration. After initial positive developments in the number of incoming students by implementing the Bologna architecture at the University of Technology Graz (since 2004) and at the University of Technology Vienna in 2006 (*Figure 1)* in the first year, the figures are now approximating the mean of incoming student over the last 10 years.

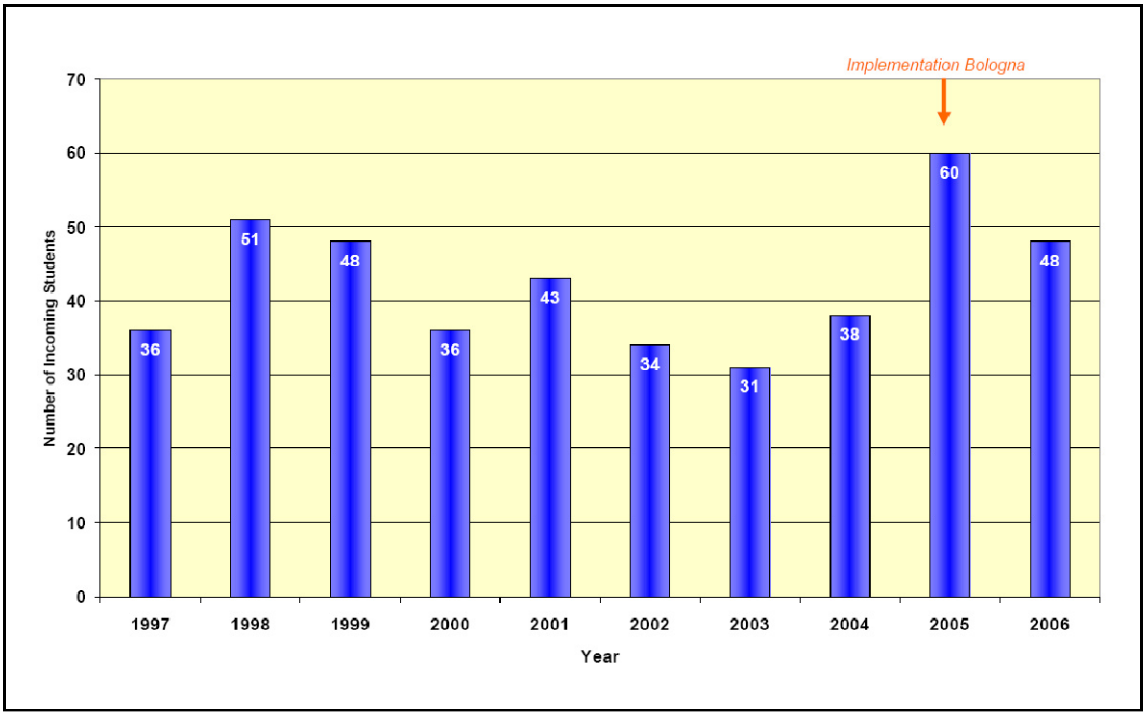


Fig. 1: Incoming students in surveying at the University of Technology in Vienna and at the University of Technology in Graz (since 2004).

3. POSSIBLE REASONS FOR DECREASED INTEREST IN SURVEYING STUDIES

What are the reasons for the decreased interest of young people to study surveying in Central Europe? Is the surveying profession itself to unattractive for today's young people? Is the low number of surveying students the result of an insufficient and inadequate education? Is it only a missing or wrong marketing of the surveying study and/or the surveying profession?

In the following chapters these questions will be discussed.

3.1 Narrow and old-fashioned occupational area?

A frequently given answer of many Austrian surveying students about their motivation to study surveying was their expectation "*to do field work by land surveying and to have close contact to people*". Now many of them are spending most of the time in a public or a private office engaged with a lot of management duties, employed with ITC-activities, or they are concerned with consulting tasks and planning activities. The discrepancy between the expectations of incoming students and the real field of professional work can be interpreted as a wrong picture of the surveyor profession in our society.

In the Austrian public a surveyor is often seen as

- a pure technician with an excellent knowledge in mathematics and geometry,
- a person needed for the procedure of buying or selling land,
- an archivist of parcels and boundary lines,
- a mathematician and sometimes pedantic person with a specific liking of high-accurate surveying instruments,
- a person providing geometrical information for civil engineers, spatial planners and other engineering professionals.

And finally the surveying profession is seen as a job only for male persons. This fact also becomes obvious by the low percentage of female students in surveying courses.

In reality the field of surveying activities has to be seen as a much broader one. The professional and educational profile of surveyors is a combination of the areas of measurement science and land administration, supported by and embedded in a broad multidisciplinary paradigm of spatial information management (Enemark, 2000). The field of activities is ranging from the mainly measuring activities to – especially in the Anglican countries - land management activities (geodesy, engineering surveying, facility management, GIS technology & mapping, land & cadastral surveying, spatial planning, and environmental resource management).

3.2 Missing possibilities for employment?

In Austria the opinion about job perspectives in surveying are a little bit varying. The educational institutions see a huge demand on graduates in surveying profession whereas many of the licensed surveyors assume a tight market. The truth must be somewhere between.

In the last decades the introduction of modern surveying instruments and of computers had shortened and simplified all measuring-, calculating-, and mapping-procedures with the result of a higher efficiency and effectiveness in most of the technical surveying tasks. Due to the simplification of surveying processes other related engineering professions are doing surveying tasks by their own. Nowadays surveying instruments and technologies, like Total Stations, GPS, and GIS are used by civil engineers, landscape engineers, spatial planners, architects, and many other professions. By developing modern data acquisition and mapping systems with a high degree on automation and by providing expert systems in the field of GIS the surveyors reduced their jobs by themselves and decreased possibilities for their own employment. Additionally the working market of surveyors shrank in Central Europe by outsourcing surveying tasks to low-wage countries.

On the other hand, surveyors captured new markets for their profession: GPS technology requires many experts in geodesy, WebGIS applications (eGovernment), risk management and global change opens huge possibilities on the labour market for surveyors, and – due to the specific situation in Austria – real estate management and land management are unexplored activity and employment fields for the surveyors.

3.3 Inadequate education and/or wrong marketing of surveying studies?

The professional fields of surveyors are in a fast and dynamic change. Within the last 20 years new disciplines and methods of spatial data management raised up: satellite geodesy, digital photogrammetry, facility management, laser scanning, WebGIS, software engineering, industrial surveying, etc. Knowledge in management, social and legal sciences became MUSTS for the surveying profession. Of course the responsible authorities in academic education and training tried to modify and to adapt the provided study courses to meet the challenges of the new professional tasks. But restrictions in the maximum of lecture hours – tightened by the Bologna process – led to the actual situation of curricula with a wide spread palette on scientific disciplines on the expense of basic education in technical and natural sciences.

Some years ago in many countries a discussion started about the name of study courses. It was realised that the term *surveying* or *geodesy* cannot fully cover all the new contents of the provided academic education. Some universities all over the world renamed their study courses to *geomatics* or *geoinformatics*, which are describing the broad spectrum of education in a better way and which are terms that are more modern. The result of this renaming process was that the public-known profession *surveyor* did not any longer fit with the name of a specific academic education, probably caused by an insufficient public relation of the new study courses or the missing translation of these new created terms to the specific national language.

Another marketing problem of surveying studies can be identified: In many of the Central European Countries surveying courses are provided by Technical Universities. Therefore students in general are expecting the main focus on subjects of technical sciences (geodesy, surveying, mechanics, and electronics) and of natural sciences (mathematics, informatics, physics, astronomy, etc.). Due to missing information of the new contents, the young people are not aware about the integration of social and human sciences in the current curricula. It is a fact that technical and natural subjects are a disincentive to many potential students – especially to female students.

4. STRATEGIES TO IMPROVE INTEREST FOR SURVEYING STUDIES

The raising questions are:

- How to attract surveying courses for young people and how to improve the role of surveyors in society?
- Who are the potential players to promote our profession and the appropriate education?
- Should promotion of profession be done on a local, national or global level?
- Which measures have to be done or have to be enhanced to bring students to the lecture halls of surveying institutes?

Possible answers to some of these questions will be given in the following chapters.

4.1 Extension of professional activities

Especially in the Central European Countries the surveyors have to extend their professional fields. The potential of working activities are manifold as described in the "FIG-Definition of Surveyors" (www.fig.net, 2006 and Magel, 2006) outlining the potential role of surveyors, as

- *Stabilisers of public order* and the work of surveyors as a precondition of a flourishing economy.
- *Guardians* of rights of property and user as well as *Guardians* for a safe system of records in land administration systems.
- *Producers, Administrators* and *Distributors* of local, national and global spatial data infrastructure.
- *Managers* of land, water and other natural resources.
- *Enablers, Mediators and Advisors* for urban and rural planning and development, including conflict resolution.
- *Hinges* (Interfaces) in global, national and local early warning systems for disaster prevention and risk management.
- *Active partners* in the development and use of e.g. global navigation satellite systems (GNSS) and high resolution imaging systems.

The professional activities are very diverse depending to national or regional regulations. Leadership in the described roles is taken very often by other professions, like lawyers, spatial planners, physicists, or computer scientists.

To make the profession more attractive and to motivate young people to study surveying, the surveyors and the surveying associations have

- *to extend their professional activities to all potential and above mentioned tasks and to strengthen the cooperation with related professional bodies on national and international level*

  It is necessary to take much more notice of the professional profiles of colleagues in other countries – there is much to learn about their broad field of work. Professional bodies must promote this international transfer of knowledge.

- *to take leadership in all described roles*

  Surveyors must become more and more managers of geodata – it cannot be enough for the profession only to play the role of data acquisitions.

- *to enter strategic partnerships with local, national and international authorities and to increase their self-confidence in the cooperation with politicians and other professions*

  Surveyors have to take leadership in current political discussion concerning land and they have show up their competence in all land issues.

- *to think about new fields of profession and new value-added products and to enter new alliances with other professions*

  Surveyors have to develop new products and services for the public community. They must be courageous in creating all-in-one-activities (one-stop-shop).

4.2 Promotion and marketing of profession and surveying education

The image of the profession in the public is very different to the occupational area of surveyors (outlined in chapter 3.1). Only a small part of surveyor's activity palette is realised by the public. As proofed by discussions people are often surprised about the multiple tasks and performances of the surveying profession. For example, it is mostly unknown that surveying (geodesy) is a fundamental part of global navigation satellite systems and people are not aware that almost all decision making is based on geographical information provided by surveyors.

FIG is on good way to promote the broad field of the surveying profession. The intensified communication with politicians and global non-governmental organisations as well as the close cooperation with sister organisations helps to advertise the manifold competences (knowledge competence, cognitive competence, business competence, ethical and/or personal behavioural competence, Plimmer, 2000) of the surveying profession.

To make the profession more attractive and to motivate young people to study surveying, the surveyors and the surveying associations have

- to organize concerted actions on national and international level for making the real occasional area of surveying profession popular,
- to communicate the important contributions of the surveying profession for the society, the economy, and the environment to the public,
- to intensify the participation in the public discussion to all land-related issues,

- to communicate the broad field of profession and the manifold activities of surveyors to young people (potential students),
- to inform incoming students about all different branches in surveying studies (measuring sciences, land management),
- to promote the surveying profession in the primary and secondary education,
- to support colleagues in countries or region with lacking or missing surveying education in their efforts to improve the situation, and
- to encourage women and other underrepresented groups in the surveying profession to enrol study courses in surveying.

4.3 Adaptation and modernisation of curricula (including CPD)

Within the last years, academic institutes were endeavoured to modify curricula to the actual needs of the surveying profession. New surveying, modelling and mapping technologies were integrated to the teaching programmes. To fulfil the requirements for the new professional profile of surveyors the current curricula with their traditional fields of natural and technical sciences were extended with contents of social and human sciences *(Figure 2)*. Nowadays surveying students are gaining knowledge on soft skills, management tools and legal sciences (Lam, 2006).

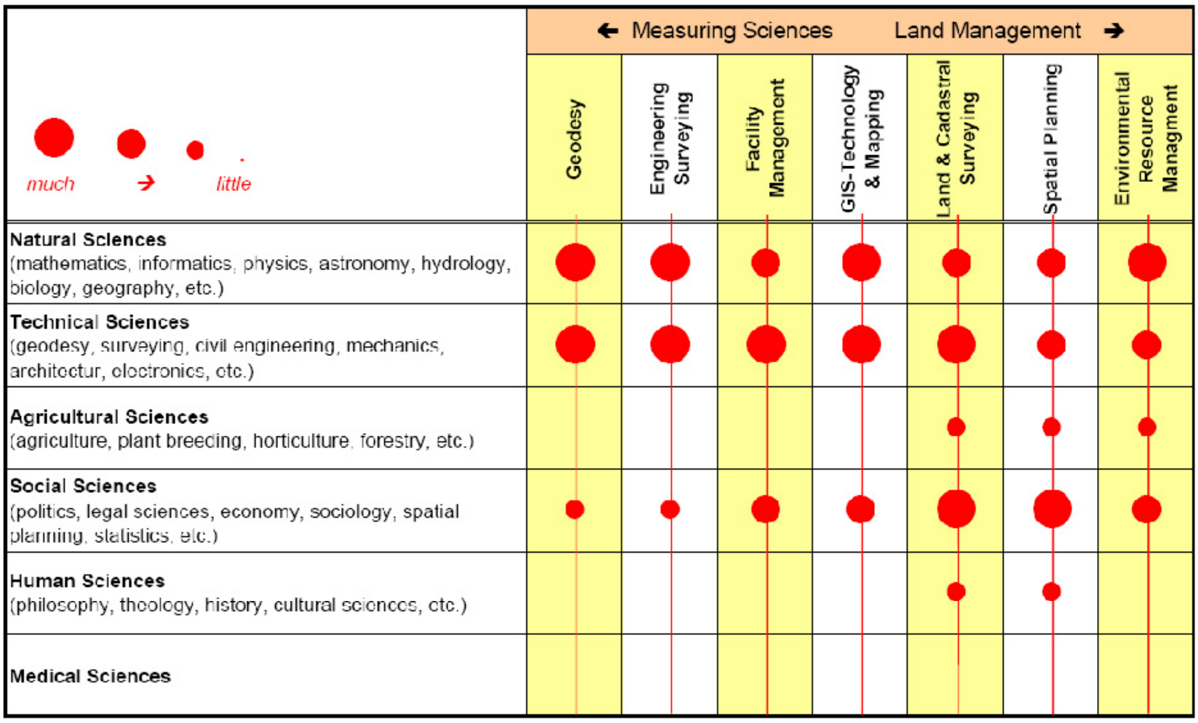


Fig. 2: Skills in fields of sciences needed for specific branches in surveying

The prompt adaptation of most of the European study programs in surveying to a three-cycle system (bachelor / master / PhD) to fulfil the requirements of the Bologna Agreement is an indicator for the engagement of European academic surveyors in educational issues (Mansberger et al, 2006b). Finally, all over the world modern teaching and learning methods

(Sørensen and Enemark, 2006, Mansberger et al, 2006a) became part of the surveying education to enable an optimal knowledge transfer to students.

However, there are still additional possibilities, to make the surveying studies more attractive and to motivate young people to study surveying. The surveyors and the surveying associations have

- *to adapt furthermore curricula to the new challenges of profession*

  The responsible persons of the academic education institutions have to tune the curricula to the topics, services and products of the future. Interests of individual surveying institutes or persons at the university, who want to favour their specific research topics more, have to be neglected.
- *to provide up-to-date teaching and learning technologies to the students*

  Lectures have to be skilled in modern teaching and learning methods. Universities have to enable a proper pedagogic and didactic education to them.
- *to intensify the mutual cooperation between all institutions involved in surveying education on a national and international level*

  Regular contact between the institutions has to be institutionalised to enable knowledge exchange between teachers and students.
- *to create new inter-university study courses on national and international level*

  Surveying institutes have to enhance their contact to other academic institutions with a different portfolio on scientific fields and they have to discuss possible interdisciplinary study courses.
- *to provide CPD (continuous-professional-development)/ LLL (life-long-learning) to all academics in the profession*

  Life and development is so fast, that there is much more need for CPD – but there are also few interesting offers!

5. SUMMARY AND CONCLUSIONS

Due to the introduction of new public management with its business-orientated objectives, the decreasing number of incoming students is a potential danger that university managers will reduce or even cancel surveying education at Austrian universities. This would be in contradiction to the current demand on surveyors in general and on academic surveyors in particular.

Therefore, stakeholders in the surveying profession have to develop sustainable strategies and perform proper measures to enhance the interest for surveying studies. They have to improve the marketing for the surveying studies, for the surveying profession itself and for all the products and services provided by the surveying profession. As all over the globe the academic surveying institutions have to face similar figures of decreasing numbers of incoming students, the promotion has to be accorded and supervised on an international level.

In Central Europe surveyors have to extend their activity fields to planning activities and to real estate management. As a first step, the academic institutions have to adapt the curricula to the demands of the broader occasional area.

Surveyors have to increase their self-confidence in the public discussion of all land- and environmental-related topics. They have to comment all political or legal decisions in the context of land, and surveyors have to point out their valuable contributions to meet the challenges of global *mega-topics* (e.g. global change, achievement of millenniums goals).

REFERENCES

Enemark, S. (2000). Merging the Efforts of CLGE and FIG to Enhance Professional Competence. In Enhancing Professional Competence of Surveyors in Europe. A joint CLGE/FIG report edited by Stig Enemark and Paddy Prendergast. ISBN 87-90907-11-6. pp 12-18. Published by The International Federation of Surveyors (FIG) and The Council of European Geodetic Surveyors (CLGE). Copenhagen, Denmark.

Geofuture (2007). Informationsportal für Berufe in Vermessung, Geodäsie, Geomatik, Geoinformatik. http://www.geofuture.de/ueberblick/ueberblick.htm. Access: 26th March 2007.

Geoinfo (2007). Offizielle Website der Studienrichtung Vermessung und Geoinformation. Last access: 27th March 2007. http://vg.geoinfo.tuwien.ac.at/index.php?go=beruf

Gromann, A. (1932). Offizielle Warnung vor dem geodätischen Berufsstudium. In: Österreichische Zeitschrift für Vermessungswesen, 1932. Wien.

Lam, S. (2006). Business Management for Geomatics Education. In: Proceedings of the, XXIII International FIG Congress, 8. - 13. October 2006, Munich. International Federation of Surveyors. 2006. Last access: 27th March 2007. http://www.fig.net/pub/fig2006/papers/ts25/ts25_05_lam_0355.pdf

Liessmann, K.P. (2006). Theorie der Unbildung. Die Irrtümer der Wissensgesellschaft. Paul Zsolnay Verlag. ISBN-10: 3-552-05382-4. Wien. 2006.

Magel, H. (2006). Shaping the Change 2002 to 2006 – The German Period of FIG. In: Proceedings of the, XXIII International FIG Congress, 8. - 13. October 2006, Munich. International Federation of Surveyors. 2006. Last access: 27th March 2007. http://www.fig.net/pub/fig2006/papers/opening/opening_magel_eng_1115.pdf.

Mansberger, R., Schuh, H., Steinkellner, G. (2006a): Impacts of the Bologna Process and of New Public Management on the Academic Surveying Education in Austria. In: Proceedings of the, XXIII International FIG Congress, 8. - 13. October 2006, Munich. International Federation of Surveyors. 2006. Last access: 27th March 2007. http://www.fig.net/pub/fig2006/papers/ts25/ts25_01_mansberger_etal_0735.pdf

Mansberger, R., Bauer, T., Heine, E. (2006b). Der Einsatz von computerbasierten Lehr- und Lernmethoden (e-Learning) in der Geomatik-Ausbildung. Österreichische Zeitschrift für Vermessung und Geoinformation. Heft 3/2006. Wien.

Plimmer, F. (2000). Professional Competence Models in Europe. In Enhancing Professional Competence of Surveyors in Europe. A joint CLGE/FIG report edited by Stig Enemark and

Paddy Prendergast. ISBN 87-90907-11-6. pp 50-75. Published by The International Federation of Surveyors (FIG) and The Council of European Geodetic Surveyors (CLGE). Copenhagen, Denmark.

Sørensen, E., Enemark, S. (2006). Problem Based Internship in Surveying and Planning Curricula. In: Proceedings of the, XXIII International FIG Congress, 8. - 13. October 2006, Munich. International Federation of Surveyors. 2006. Last access: 27th March 2007. http://www.fig.net/pub/fig2006/papers/ts34/ts34_05_sorensen_enemark_0790.pdf

BIOGRAPHICAL NOTES

Reinfried MANSBERGER currently works as an Assistant Professor at the Institute of Surveying, Remote Sensing and Land Information at the University of Natural Resources and Applied Life Sciences, Vienna (BOKU Wien). In 1982 he obtained his Master's degree in surveying at the Vienna University of Technology. He obtained his PhD degree at the BOKU Wien. He is in the editorial board of Ashgate "Land Management Book Series" and involved in FIG as Austrian delegate of Commission 2. Reinfried Mansberger is an elected member of the European Faculty of Land Use and Development and Council member of the Austrian Society of Surveying and Geoinformation. His research work is focusing on Land Use Planning, Land Information, Environmental GIS Applications, and Cadastral Systems.

Gert STEINKELLNER currently works as Head of the Department for International Affairs at Federal Office of Metrology and Surveying (BEV). Until 2006 he chaired the Section for Training and Education at BEV. He is representing Austria as a delegate in Commission 2 (Professional Education) since 1992. In 2006 he became chair of Working Group 2.3 (Educational Management and Marketing). Since 2003 he is elected President of the Austrian Society for Surveying and Geoinformation (OVG). Gert Steinkellner received his master degree for surveying in 1983 at Vienna University of Technology. His involvement in national and international projects as well as his cooperation in international networks focuses on the topics Learning, Education and Human Resource Management.

CONTACT

Ass.Prof. Dipl.-Ing. Dr. Reinfried MANSBERGER
Institute of Surveying, Remote Sensing and Land Information (IVFL)
University of Natural Resources and Applied Life Sciences (BOKU Wien)
Peter Jordan-Strasse 82
A-1190 Vienna,
AUSTRIA
Tel.: +43/1/47 654-5115
Email: mansberger@boku.ac.at
Web site: http://www.rali.boku.ac.at/ivfl.html

Dipl.-Ing. Gert STEINKELLNER
Federal Office of Metrology and Surveying (BEV) and
Austrian Society for Surveying and Geoinformation (OVG)
Schiffamtsgasse 1-3
A-1025 Vienna,
AUSTRIA
Tel.: +43/1/21176-2714; Mobile +43/676/8210-2714
Email: gert.steinkellner@bev.gv.at
Web sites: www.bev.gv.at and www.ovg.at

Celestial Mechanics as a Part of Geodesist's Curriculum

Leoš MERVART, Zdeněk LUKEŠ, Czech Republic

Key words: celestial mechanics, geodesy, education

SUMMARY

The celestial mechanics, science dealing with the orbital and rotational motion of celestial bodies, belongs to the oldest scientific disciplines. Its modern history began in the 16th century with the epoch of Tycho Brahe and Johannes Kepler. Since that time astronomers and scientists working in this branch have achieved a number of brilliant results. Taking into account the increasing impact of satellite techniques on surveying, the question of incorporating celestial mechanics into the standard curriculum of subjects being taught within geodetic courses arises. This paper tries to touch the problem in three closely related aspects. The problem of orbit determination is introduced in the first section. The second section lists the mathematical background that is necessary for solving the problem. The third section introduces two software tools that may be used in the educational process.

1. ORBIT DETERMINATION

Orbit determination can be viewed as a special case of a general parameter estimation problem, where the *parameters* characterizing the orbit of an artificial Earth satellite, have to be determined from *observations*. Observations are – apart from the unavoidable observation errors – values of functions (the so-called *observed functions*) of the parameter estimation problem considered. In our application the observed functions are *nonlinear* in the orbit parameters. *Nonlinearity* and the fact that initially there may be *no approximate values available for the orbit parameters* are the essential difficulties of the orbit determination problem. The orbit parameters must uniquely specify one particular solution of the equations of motion and (possibly) the force field acting on the object. In a *pure orbit determination problem* the forces acting on the bodies are assumed to be known as a function of the bodies' positions (and possibly velocities). In this case, the orbit parameters are uniquely quantities defining the initial state (position- and velocity-vector of the orbit), at a particular epoch t_0. This section deals with a relatively new type of orbit determination problem, namely that of deriving orbits using the measurements of onboard GPS receivers. The orbit determination problem may be solved with standard procedures of applied mathematics, *provided* a set of approximate orbit parameters of a sufficiently high accuracy is already available. If such approximations are available we speak of an *orbit improvement problem*, because we "merely" have to improve the known approximate parameters. This task is considered in the following paragraph.

The so-called *equation of motion* expresses the satellite's acceleration as a function of time t, satellite position, satellite velocity and the dynamic parameters $\mathbf{p}$:

$$\ddot{\mathbf{r}} = \mathbf{a}(t, \mathbf{r}, \dot{\mathbf{r}}, \mathbf{p}) \; , \quad \mathbf{p} = \begin{pmatrix} p_1 \\ \vdots \\ p_n \end{pmatrix}$$

In addition the so-called initial conditions are given by:

$$\begin{aligned} \mathbf{r}(t_0) &= \mathbf{r}_0 \\ \dot{\mathbf{r}}(t_0) &= \mathbf{v}_0 \end{aligned}$$

In order to transform the second-order differential equation into a first-order equation we introduce the so-called *state vector*

$$\mathbf{y} = \begin{pmatrix} \mathbf{r} \\ \dot{\mathbf{r}} \end{pmatrix}$$

and receive the corresponding first-order differential equation of motion in form

$$\dot{\mathbf{y}} = \begin{pmatrix} \dot{\mathbf{r}} \\ \ddot{\mathbf{r}} \end{pmatrix} = \begin{pmatrix} \dot{\mathbf{r}} \\ \mathbf{a}(t, \mathbf{r}, \dot{\mathbf{r}}, \mathbf{p}) \end{pmatrix} = \mathbf{f}\,(t, \mathbf{y}, \mathbf{p})$$

with initial conditions

$$\mathbf{y}(t_0) = \begin{pmatrix} \mathbf{r}_0 \\ \mathbf{v}_0 \end{pmatrix}$$

which is more appropriate for numerical integration algorithms. Mathematically the orbit determination problem is thus defined as solving for initial conditions and dynamic parameters using some observations. In case of space-borne GPS receiver the pseudo-range observations are given as

$$P' = P + c\delta^i = \varrho + c\delta_k$$

where ρ is (in first approximation) the geometric distance between the GPS satellite and the (space-borne) receiver and $c\delta_k$ is the (unknown) receiver clock error (in units of length). Introducing the so-called transition matrix

$$\mathbf{\Phi} = \frac{\partial\,\mathbf{y}}{\partial\,\mathbf{y}_0} = \begin{pmatrix} \dfrac{\partial\,\mathbf{r}}{\partial\,\mathbf{y}_0} \\ \dfrac{\partial\,\dot{\mathbf{r}}}{\partial\,\mathbf{y}_0} \end{pmatrix}$$

and the so-called *sensitivity matrix*

$$\mathbf{S} = \frac{\partial\,\mathbf{y}}{\partial\,\mathbf{p}}$$

we can express one line of the *first design matrix* as

$$\mathbf{A}(i:i) = \frac{\partial\,(\varrho + c\delta_k)}{\partial\,\mathbf{X}} = \left(\frac{\partial\,\varrho}{\partial\,\mathbf{r}}\boldsymbol{\Phi}(1:3) \quad \frac{\partial\,\varrho}{\partial\,\mathbf{r}}\mathbf{S}(1:3) \quad 1\right)$$

where **X** is the vector of all unknowns (it comprises the 6 initial conditions, the dynamic parameters, and the receiver clock error). It can be seen that the only question now is how to compute the transition and sensitivity matrices. The most common way for it is the usage of the so-called *variational equations*. For the transition matrix the corresponding variational equations read as

$$\dot{\boldsymbol{\Phi}} = \begin{pmatrix} \dfrac{\partial\,\dot{\mathbf{r}}}{\partial\,\mathbf{y}_0} \\ \dfrac{\partial\,\ddot{\mathbf{r}}}{\partial\,\mathbf{y}_0} \end{pmatrix} = \begin{pmatrix} \dfrac{\partial\,\dot{\mathbf{r}}}{\partial\,\mathbf{y}}\dfrac{\partial\,\mathbf{y}}{\partial\,\mathbf{y}_0} \\ \dfrac{\partial\,\ddot{\mathbf{r}}}{\partial\,\mathbf{y}}\dfrac{\partial\,\mathbf{y}}{\partial\,\mathbf{y}_0} \end{pmatrix} = \begin{pmatrix} \dfrac{\partial\,\dot{\mathbf{r}}}{\partial\,\mathbf{y}} \\ \dfrac{\partial\,\mathbf{a}}{\partial\,\mathbf{y}} \end{pmatrix} \boldsymbol{\Phi}$$

with initial conditions

$$\boldsymbol{\Phi}(t_0) = \mathbf{I}$$

for the sensitivity matrix the variational equations have the form

$$\dot{\mathbf{S}} = \begin{pmatrix} \dfrac{\partial\,\dot{\mathbf{r}}}{\partial\,\mathbf{p}} \\ \dfrac{\partial\,\ddot{\mathbf{r}}}{\partial\,\mathbf{p}} \end{pmatrix} = \begin{pmatrix} \dfrac{\partial\,\dot{\mathbf{r}}}{\partial\,\mathbf{y}}\dfrac{\partial\,\mathbf{y}}{\partial\,\mathbf{p}} \\ \dfrac{\partial\,\ddot{\mathbf{r}}}{\partial\,\mathbf{y}}\dfrac{\partial\,\mathbf{y}}{\partial\,\mathbf{p}} + \dfrac{\partial\,\ddot{\mathbf{r}}}{\partial\,\mathbf{p}} \end{pmatrix} = \begin{pmatrix} \dfrac{\partial\,\dot{\mathbf{r}}}{\partial\,\mathbf{y}} \\ \dfrac{\partial\,\mathbf{a}}{\partial\,\mathbf{y}} \end{pmatrix} \mathbf{S} + \begin{pmatrix} \mathbf{0} \\ \dfrac{\partial\,\mathbf{a}}{\partial\,\mathbf{p}} \end{pmatrix}$$

with initial conditions

$$\mathbf{S}(t_0) = \mathbf{0}$$

Assuming that a priori values $\mathbf{X}_0$ of all unknown parameters are known and introducing the so-called reduced observations of form

$$\ell = P' - \varrho_0(\mathbf{r}(\mathbf{X}_0))$$

we may conclude that all pre-requisites are ready for the estimation of the orbit using e.g. the standard least-squares adjustment algorithm.

2. MATHEMATICAL BACKGROUND

In previous section we have outlined the basics of the orbit determination. We admit that not all surveyors will be challenged with such task in their practice and that actual orbit computations are done by specialists. On the other hand one can argue that these specialists are often being recruited among geodesist and the geodesists and surveyors that are using the satellite techniques should be aware of their principles and limitations. From that point of view we think that some parts of the celestial mechanics truly belong to geodesists' curriculum. So, let us try to list the mathematic skills that are necessary for understanding the celestial mechanics.

In spite of that we have called this section "Mathematical Background", it is the physics that comes to foreground first. On the right-hand side of the equation of motion the acceleration that is induced by forces acting on the satellite is expressed as a function of time, satellite position and satellite velocity. Assuming an artificial satellite in the vicinity of the Earth body, at least the following forces have to be taken into account:

1. Gravity attraction of the Earth.
2. Gravity attraction of other celestial bodies (namely Moon and Sun).
3. Solar radiation pressure
4. Atmospheric drag

For the orbit determination with the highest accuracy, the following forces are also of importance:

5. Earth radiation pressure
6. Earth tides
7. Relativistic effects

Let us take the Earth gravity as an example. The non-spherical part of the gravity potential $V'(r,\beta,\lambda)$ is given by the series of spherical functions

$$V' = \frac{GM}{r} \sum_{n=2}^{\infty} \left(\frac{a_e}{r}\right)^n \sum_{m=0}^{n} P_{nm}(\sin\beta)\ (C_{nm}\ \cos m\lambda + S_{nm}\ \sin m\lambda)$$

where P_{nm} is the associated Legendre function of degree n and order m, and C_{nm}, S_{nm} are the so-called *Stoke's coefficients*. Resulting acceleration is given by the gradient of the potential

$$\vec{\nabla} V' = \underbrace{\begin{pmatrix} \partial r/\partial r_1 & \partial\beta/\partial r_1 & \partial\lambda/\partial r_1 \\ \partial r/\partial r_2 & \partial\beta/\partial r_2 & \partial\lambda/\partial r_2 \\ \partial r/\partial r_3 & \partial\beta/\partial r_3 & \partial\lambda/\partial r_3 \end{pmatrix}}_{\mathbf{D}} \begin{pmatrix} \partial V'/\partial r \\ \partial V'/\partial\beta \\ \partial V'/\partial\lambda \end{pmatrix}$$

where

$$\begin{aligned}
\frac{\partial V'}{\partial r} &= -\frac{GM}{r^2} \sum_{n=2}^{\infty} \left(\frac{a_e}{r}\right)^n (n+1) \sum_{m=0}^{n} P_{nm}(\sin\beta) \\
&\qquad (C_{nm}\ \cos m\lambda + S_{nm}\ \sin m\lambda) \\
\frac{\partial V'}{\partial\beta} &= \frac{GM}{r} \sum_{n=2}^{\infty} \left(\frac{a_e}{r}\right)^n \sum_{m=0}^{n} [P_{nm+1}(\sin\beta) - m\ \tan\beta\ P_{nm}(\sin\beta)] \\
&\qquad (C_{nm}\ \cos m\lambda + S_{nm}\ \sin m\lambda) \\
\frac{\partial V'}{\partial\lambda} &= \frac{GM}{r} \sum_{n=2}^{\infty} \left(\frac{a_e}{r}\right)^n \sum_{m=0}^{n} m\ P_{nm}(\sin\beta) \\
&\qquad (-C_{nm}\ \sin m\lambda + S_{nm}\ \cos m\lambda)
\end{aligned}$$

and the elements of matrix **D** are given by

$$\frac{\partial r}{\partial r_1} = \frac{r_1}{r}\,,\ \frac{\partial r}{\partial r_2} = \frac{r_2}{r}\,,\ \frac{\partial r}{\partial r_3} = \frac{r_3}{r}$$

$$\frac{\partial \beta}{\partial r_1} = \frac{-r_1 r_3}{r^2\sqrt{r_1^2+r_2^2}}\,,\ \frac{\partial \beta}{\partial r_2} = \frac{-r_2 r_3}{r^2\sqrt{r_1^2+r_2^2}}\,,\ \frac{\partial \beta}{\partial r_3} = \frac{\sqrt{r_1^2+r_2^2}}{r^2}$$

$$\frac{\partial \lambda}{\partial r_1} = \frac{-r_2}{r_1^2+r_2^2}\,,\ \frac{\partial \lambda}{\partial r_2} = \frac{r_1}{r_1^2+r_2^2}\,,\ \frac{\partial \lambda}{\partial r_3} = 0$$

Mathematical model for the gravity attraction of Moon and Sun is much simpler because it is usually sufficient to assume these bodies being point masses (their dimensions are negligible with respect to their distances). The complexity of the solar radiation pressure model and the atmospheric drag model depends on the orbit parameters (e.g. height of the satellite orbit above the Earth surface) and, of course, on the required accuracy.

The equations of motion are special cases of the following explicit system of ordinary differential equation systems of order *n*:

$$\boldsymbol{y}^{(n)} = \boldsymbol{f}\big(t, \boldsymbol{y}, \dot{\boldsymbol{y}}, \ddot{\boldsymbol{y}}, \ldots, \boldsymbol{y}^{(n-1)}\big)$$

Many algorithms for the numerical solution of differential equations may be used to solve only first-order differential equation systems. From the mathematical point of view, no harm is done by this restriction, because every higher-order system may be transformed into a first order system by the following substitutions:

$$\begin{aligned}
\boldsymbol{u}_0 &\overset{\text{def}}{=} \boldsymbol{y} \\
\boldsymbol{u}_1 &\overset{\text{def}}{=} \dot{\boldsymbol{y}} \\
\ldots &\overset{\text{def}}{=} \ldots \\
\boldsymbol{u}_i &\overset{\text{def}}{=} \boldsymbol{y}^{(i)} \\
\ldots &\overset{\text{def}}{=} \ldots \\
\boldsymbol{u}_{n-1} &\overset{\text{def}}{=} \boldsymbol{y}^{(n-1)}
\end{aligned}$$

These transformations allow it to set up the following first order system of differential equations:

$$\dot{\boldsymbol{u}} = \boldsymbol{F}(t, \boldsymbol{u})$$

where

$$\boldsymbol{u} \overset{\text{def}}{=} \begin{pmatrix} \boldsymbol{u}_0 \\ \boldsymbol{u}_1 \\ \ldots \\ \ldots \\ \boldsymbol{u}_{n-1} \end{pmatrix} \quad \text{and} \quad \boldsymbol{F}(t, \boldsymbol{u}) \overset{\text{def}}{=} \begin{pmatrix} \boldsymbol{u}_1 \\ \boldsymbol{u}_2 \\ \ldots \\ \ldots \\ \boldsymbol{u}_{n-1} \\ \boldsymbol{f}(t, \boldsymbol{u}) \end{pmatrix}$$

There are many algorithms for the numerical solution of differential equations. The Runge-Kutta methods are particularly easy to use and may be applied to a wide range of different problems. The so-called multistep methods provide a high efficiency but require a storage of past data points. The so-called extrapolation methods are famous for their high accuracy.

The best-known Runge-Kutta algorithm undoubtedly is that of order q = 4, that is probably reproduced in every treatment of numerical analysis: the value of the function that is being sought at time t_0+h is computed as

$$\boldsymbol{y}(t_0 + h) = \boldsymbol{y}_0 + \boldsymbol{k}_m$$

where

$$\boldsymbol{k}_m = \tfrac{1}{6}\left(\boldsymbol{k}_1 + 2\,\boldsymbol{k}_2 + 2\,\boldsymbol{k}_3 + \boldsymbol{k}_4\right)$$

and

$$\begin{aligned}
\boldsymbol{k}_1 &= h\,\boldsymbol{f}(t_0, \boldsymbol{y}_0)\\
\boldsymbol{k}_2 &= h\,\boldsymbol{f}\left(t_0 + \tfrac{1}{2}\,h, \boldsymbol{y}_0 + \tfrac{1}{2}\,\boldsymbol{k}_1\right)\\
\boldsymbol{k}_3 &= h\,\boldsymbol{f}\left(t_0 + \tfrac{1}{2}\,h, \boldsymbol{y}_0 + \tfrac{1}{2}\,\boldsymbol{k}_2\right)\\
\boldsymbol{k}_4 &= h\,\boldsymbol{f}\left(t_0 + h, \boldsymbol{y}_0 + \boldsymbol{k}_3\right)
\end{aligned}$$

Unfortunately it has been shown that, among Runge-Kutta methods, only high order methods are reasonable candidates for the accuracy requirements of orbit computations. The selection of a proper numerical algorithm thus requires quite a lot of knowledge and experience.

We may conclude that *understanding of the mathematical model* of the Earth satellite motion requires the knowledge of the following parts of mathematics:

1. Mathematical analysis.
2. Linear algebra.
3. Differential equations.
4. Theory of spherical harmonics.

Practical computations require furthermore the knowledge of

5. Least-squares adjustment.
6. Numerical solution of differential equations.

To make the long story short, we may end this section with the conclusion that the *mathematics behind the satellite geodesy* is quite advanced and sometimes *goes beyond the level that is usual for undergraduate math courses* that are taught (in case of our technical university) during the first four semesters.

3. SOFTWARE TOOLS

In previous sections we have tried to pick out and sketch a few keystones of the orbit determination problem and to compile a list of pieces of mathematical knowledge that putted together allow the students to understand and successfully solve the problems of celestial mechanics. For didactic purposes it is highly desirable to accompany the theory with examples and exercises. However, celestial mechanics can be hardly demonstrated without computers and appropriate software tools. In this section we want to introduce two software tools that may be used for teaching satellite geodesy.

Until recently nobody could think about the celestial mechanics as about an experimental science. The power of modern computers allows modeling of celestial bodies' motion in time spans of millions of years. Using the numerical methods for solving the differential equations describing the planetary systems it is possible to test cosmologic hypothesis, to study the stability of the systems and to make true "experiments" by varying the initial conditions. In such a way the celestial mechanics receives a new dimension as an experimental science.

3.1 Methods of Celestial Mechanics

Professor Gerhard Beutler, the current president of the International Association of Geodesy and the head of the Astronomical Institute, University of Berne, has a long time experience with the application of numerical methods on the problems of the celestial mechanics. He has summarized his scientific life-experience in his textbook on the celestial mechanics [1] and [2]. First author of this paper have had an opportunity to cooperate with professor Beutler during the preparation of the book. The computer programs represent an integral part of this compendium of celestial mechanics. The programs should help the reader to better understand the theory, stimulate him to make experiments and to have (perhaps) more "fun" when reading and digesting the main body of the book. Here is the list of the programs:

- NUMINT numerically solves the non-linear equations of motion associated with satellite and minor planet orbits.

- LINEAR allows solving nine selected linear problems (e.g. exponential function, harmonic oscillator, Bessel's differential equation, and Legendre differential equation).

- ORBDET may be used to determine the orbits of minor bodies in the planetary system and the orbits of artificial Earth satellites and of space debris.

- SATORB may be used to generate satellite orbits or to determine the orbits of satellites using tabular satellite positions as pseudo-observations or astrometric places as real observations.

- LEOKIN computes the positions of the so-called Low Earth Orbitals (i.e. artificial Earth satellites on low orbits).

- ERDROT solves the equations of Earth rotation and the three-body problem Earth-Moon-Sun assuming that Earth and Moon are rigid bodies.

- PLASYS allows studying the evolution of the planetary system.

- FOURIER may be used for various forms of spectral analysis.

An impression on the look of the celestial mechanics software package can be obtained from the following figure:

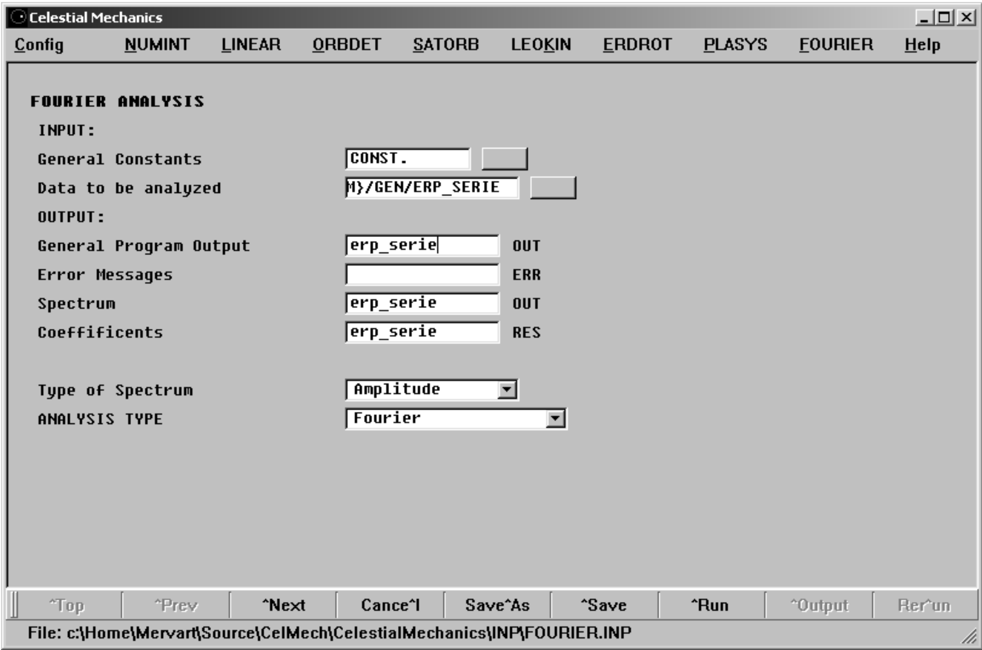


Fig. 1: Celestial mechanics software package

The program options are contained in one or more input panels. The user may browse through the panels, he may change program input options and run the executable programs using a user-friendly menu system that guides him by reporting some invalid options (e.g., non-existing input files, missing output file names, etc.). As far as the visualization of results is a very important step of data analysis, the system provides its own way of plotting the program results. An example of the results of ERDROT program is shown in the following figure:

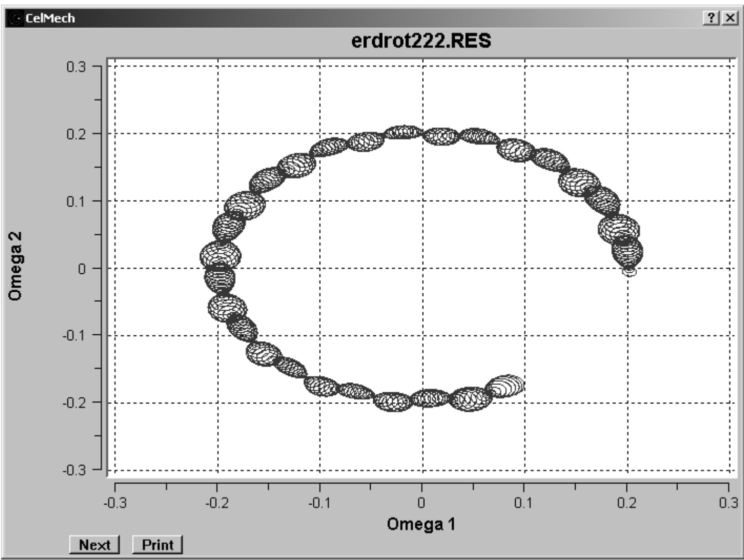


Fig. 2: An example of the results of ERDROT program

3.2 Real-Time Orbit Determination Program rtorb

Program rtorb has been developed by the authors of this paper for orbit determination of satellites equipped by GPS receivers. Nowadays there is a wide range of Earth satellites whose trajectories are being precisely determined using GPS observations.

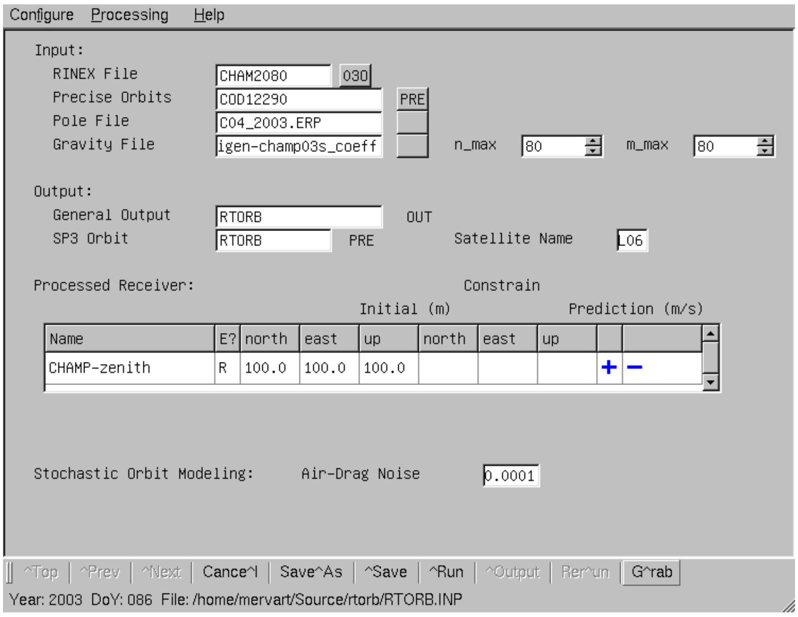


Fig. 3: Program rtorb

Currently, the typical application is the orbit determination of low Earth orbiters in post-processing mode. Rtorb is capable of processing data collected into files as can be seen in figure above (orbit determination of the CHAMP satellite in post-processing mode). However, the program is primarily designed for the so-called real-time orbit determination.

REFERENCES

[1] Beutler, G.: Methods of Celestial Mechanics Volume I: Physical, Mathematical and Numerical Principles, Springer-Verlag Berlin Heidelberg 2005.
[2] Beutler, G.: Methods of Celestial Mechanics Volume II: Application to Planetary System, Geodynamics and Satellite Geodesy, Springer-Verlag Berlin Heidelberg 2005.

BIOGRAPHICAL NOTES

Leoš Mervart received his first PhD (in astronomy) from the Astronomical Institute, University of Berne (Switzerland) and his second PhD (in geodesy) from the TU Prague (Czech Republic). He is co-author of the Bernese GPS Software (http://www.bernese.unibe.ch) and author or co-author of many publications on GPS data processing, algorithms and software development. 2002 L. Mervart was appointed professor of geodesy at the Technical University, Prague, where he currently leads the Institute of Geodesy.

Zdeněk Lukeš is a lecturer at the Department of Advanced Geodesy, Faculty of Civil Engineering, CTU Prague. He received his PhD in geodesy from CTU Prague in 2005. His main interests are in adjustment theory and GPS data analysis. He is a co-author of real-time GPS data processing software RTNET.

CONTACTS

Prof. Dr. Ing. Leoš Mervart, DrSc., Ing. Zdeněk Lukeš, Ph.D.
Department of Advanced Geodesy,
Faculty of Civil Engineering
Czech Technical University in Prague
Thákurova 7
166 29 Praha 6
CZECH REPUBLIC
Tel. +4202 2435 4805
Fax +4202 2435 4343
Email: mervart@fsv.cvut.cz
zdenek.lukes@fsv.cvut.cz
Web site: www.fsv.cvut.cz

Curricula in Geoinformatics at the Faculty of Science, Charles University in Prague

Markéta POTŮČKOVÁ, Eva ŠTEFANOVÁ, Tomáš BAYER, Michal LODIN, Stanislav GRILL, Czech Republic

Key words: education, geoinformatics, cartography, bachelor and master's curriculum

SUMMARY

Geoinformation disciplines have recently evolved into a new field integrating traditional surveying and mapping curricula, complemented by remote sensing and geographic information systems. This paper describes the approach in the design of a new Curriculum of Geoinformatics offered by the Department of Applied Geoinformatics and Cartography at Charles University in Prague. The Curriculum builds on a 150 year old tradition of cartography education and incorporates latest trends and technologies in geographic information systems, remote sensing, photogrammetry, global positioning systems and other related disciplines.

The need for sustainable development and environmental monitoring underline the need for incorporating spatially referenced data into existing public and private infrastructures. The concept of a Spatial Data Infrastructure has been adopted by the department as a part of the educational program. The described curriculum addresses the need for trained professionals at the Bachelor, Masters and doctoral levels by the transforming Czech Society.

1. INTRODUCTION

Applications of geographic information systems and remote sensing have been increasing in natural and social sciences as well as in technical disciplines during the last decade. This fact has caused the need of changes of the curricula of geographic studies at the Faculty of Science of Charles University in Prague. The Department of Applied Geoinformatics and Cartography has also followed these new requirements. Another reason for changes was an acceptance of the Bologna agreement. The original five years master degree study of Cartography and Geoinformatics was transformed to the bachelor (three years) and master (two years) degree studies.

The new curriculum of the bachelor and master degree programmes has been created during the last four years. To date the curriculum is accredited and used. Nevertheless, the content of each subject is being adjusted in accordance with the newest trends and development in the field of geoinformatics and cartography.

2. GEOINFORMATICS AND CARTOGRAPHY AT THE FACULTY OF SCIENCE

Cartography and Geoinformatics, as the field of study at the Faculty of Science, is not only understood as a combination of traditional sciences such as cartography, remote sensing or informatics. The emphasis is on the complex approach to the solution of geographic problems using the modern information technologies. Students should master the theory but they should learn it in context with practical applications. The results of scientific work are presented during the lectures. This helps the students to get familiar with the scientific approaches to solving different problems and it also gives the students opportunity to get involved in research activities of the department. The students have also possibilities to present results of their work at annual student conferences and they can participate in several student scientific competitions. The students should learn that the real meaning of learning geoinformatics is in understanding of spatial data and their spatial relations based on mathematical or computational principles and that it does not only represent another tool for making nice cartographic outputs.

Geoinformatics is an interdisciplinary field. It is important to conceive its education as a group of subjects connected on a common base but pointed at various professional qualifications such as research work in the field of geoinformatics, development of new methodologies and algorithms for software solutions, new applications of existing tools in specific branches such as hydrology, archaeology, etc. The curriculum at each university is created with respect to the selected professional profile of the graduates. It is obvious, that it is not realistic to cover all possible specializations within one department.

The goal of the Department of Applied Geoinformatics and Cartography is to provide such education that the graduates will be able to become professionals in geoinformatics in short time on the level corresponding to the obtained degree. Moreover, the graduates from master degree studies will be prepared to start working as researchers having not only theoretical and technical skills on corresponding level but also being knowledgeable about team work and skilled in different forms of communication.

3. STRUCTURE OF THE CURRICULUM

The new curriculum is structured to four parts: methods of scientific work, spatial data acquisition, processing and analysis, spatial data visualization and presentation, databases.
In the bachelor degree programme called Geography and Cartography, the students learn traditional geographic subjects as physical, social or regional geography (namely hydrology, geomorphology, geography of urban areas, political and regional geography etc.). Except of these, the students get familiar with the principles of geographic information systems, databases, remote sensing and cartography. The skills gained in the geoinformation subjects, the students directly apply at practical exercises of geographical disciplines and bachelor thesis. Successful graduating from bachelor studies in the field of geoinformatics, cartography, remote sensing or related fields is a condition for being accepted to the master degree programme called Cartography and Geoinformatics. The second condition is to pass an entrance examination. It is oral and the candidate has to prove professional knowledge, language skills and explain his or her motivation for the future study.

The subjects of the master programme deepen knowledge in the four above mentioned fields. The goal of the study is full understanding of principles and applications of systems for spatial data acquisition, processing, analysis, presentation and storage. The students have possibility to gain experience and knowledge by proposing and solving research projects and grants in the frame of interdisciplinary research based on cooperation with other departments and institutions of the Faculty of Science or other universities. The master degree study of Geoinformatics and Cartography is suited for a smaller group of students (approximately 20). This amount allows for an individual approach of teachers to students. Discussions about possible solutions of a given task are common parts of the practical exercises. Each student has a possibility to suggest and defend his or her solution. The emphasis is not only on finding the solution and its implementation, but it is also on its defending in the group of students and teachers. In this way, students develop their communication skills and ability to present their results.

3.1 Science and research

Introduction to University Study and Seminar in Geography are two subject of the bachelor degree programme where students learn about the basic trends in the development of the geographic thinking and about history of geography both in the Czech Republic and abroad. They get overview on research activities in contemporary geography, Czech and international geographic organizations, professional journals and publications. The terms as physical, social and regional geography, demography, cartography and geoinformatics are explained as well as the basic approaches to scientific work. The students are also informed about the structure of the geographic studies at the Faculty of Science, about the Geographic Library and about the Map Collection of Charles University. They get skills in working effectively with available information sources (bibliographic database, internet information portals). Based on practical examples, they learn how to structure written thesis that they are supposed to deliver during their study and how to refer to literature. Furthermore, they practise basic rules of presentation (with the emphasis on the performance of the speaker, design of presentation and its content).

The two mentioned subjects are followed by the Seminar for Bachelor Thesis in the third year of the study. It focuses on principles of scientific work and systematic approach to solving stated problems. The goal is to teach students to formulate basic hypothesis, work with the literature, design a methodology for solving own scientific problem and present achieved results. The students learn about general tasks to be solved in every bachelor thesis. The students are asked to explain their choice of the topic of the thesis. They have to present the structure of the thesis and the literature they work with. During the seminar, students work on some parts of their thesis. By presenting the results they get inputs from their colleagues and teachers for final defence of the thesis.

The topic of scientific and research work is developed further in the master study in two subjects. The first one, Introduction to the Master Study concentrates on general concept of geoinformatics and makes a frame for all other subjects taught on the master level. The goal of the second subject, called Diploma Project, is to prepare students for their own scientific work that will lead to successful completion of the diploma work.

3.2 Acquisition and processing of spatial data

The principles of remote sensing and its applications in geography are taught at the bachelor level. The students get also familiar with practical tasks as qualitative evaluation of spatial data, visual interpretation of remote sensing data and classification.

Three subjects deal with spatial data acquisition and processing in the master degree programme – Extraction of Topographic Information, Extraction of Information from Remote Sensing Data and Theory of Spatial Information. The aim of the subject Extraction of Topographic Information is to give an overview on the methods for data acquisition and processing, especially concerning middle and large scale mapping. Data collection by means of photogrammetry, laser scanning and RADAR techniques for the purpose of providing geometrical data for a topographic database, updating a topographic database and spatial modelling in topography are the main topics of the subject. After accomplishing this subject, the students should be able to choose an appropriate method of collecting and processing data according to the given project specifications, they should be able to compare and evaluate different methods of data collection from both the qualitative and economical point of view. Furthermore, the students should have an overview of existing topographic databases in the Czech Republic, their quality and accessibility. They should be able to explain the steps of updating topographic information and suggest methods for its solution.

The lectures of the subject Extraction of Information from Remote Sensing Data concentrate on the analysis of remote sensing data on an advanced level. The main goal is to explain image analysis in the context of extraction of information about natural resources from remote sensing data. It includes concepts of digital image segmentation, spectral classification, fuzzy logic classification, classification with combination of spatial, spectral and shape characteristics (object oriented classification) and data integration. Selected modules of the software package PCI Geomatica are used in practical exercises focused on mapping of land cover and its changes from remote sensing and aerial images and on other applications connected to obtaining information needed for dealing with natural resources.

Theory of Spatial Information describes three current problems of spatial modelling – time series (time in GIS, time presentation, spatio-temporal analysis), topology (definition, rules, implementation in GIS) and uncertainty (introduction to the theory, uncertainty in GIS, dealing with uncertain data). Each of these problems represents a key issue in working with spatial data. For applications, it is important to have understanding for and be able to work with data time series. A suitable data structure that comprises topology is necessary for being able to create and answer queries about spatial relationships. Last but not least, data quality as well as its error rate and uncertainty have to be taken into account.

3.3 Visualization and presentation of spatial data

Visualization of Spatial Data is a recommended subject of the bachelor programme. It builds on the knowledge obtained in the remote sensing. It is a practical introduction to the visualization of digital image data. Mathematical background of the algorithms and practical examples of processing of raster data of different spectral and spatial resolution are explained together with the principles of data quality assessment, changes of contrast, noise removal, enhancement or suppression of edges, local enhancement of image detail, multi-spectral synthesis, multidimensional analysis, multi-image correlation, representation of spectral, spatial and frequency domain.

There are two more subjects of the master degree programme included in the branch dealing with spatial data visualization and presentation. Distribution of Spatial Data concentrates on methods for data distribution on the Internet. The students get familiar with the computer network theories and the concepts of the Internet. They learn tools needed for designing internet applications. The attention is paid to creating of static and dynamic web outputs in connection to cartography and GIS. The important part of the course is an introduction to map publication on the internet (map servers, etc.).

The lectures of the subject Creating Interactive Maps explain algorithms widely applied in the field of digital cartography such as basic compression algorithms, classification methods used for creating thematic maps, convex and non-convex tessellations and their applications in GIS systems, algorithms for cartographic generalization of geometric parameters of different features, analyses applied above planar oriented and non-oriented graphs. The learnt theory is practically implemented during exercises in the environment of Matlab or by using programming languages as C++ or Java.

3.4 Databases

There are two subjects focused on database systems, one as a part of the bachelor and one as a part of the master degree programme.

The subject Principles of Databases gives the students basic overview on database technologies. Data models, relational algebra, query language including SQL, database architectures, the problematic of transaction processing and concurrent data access are the main topics. The exercises concentrate on practicing SQL and its standard specifications. Moreover, the students get familiar with database systems and platforms available on the market. Advantages and disadvantages of specific database technologies are discussed with respect to GIS and spatial data in general.

The following subject Database Design and Management deals with advanced database technologies. It concentrates on procedures of the design and creating of databases including explanation of appropriate tools (CASE), transaction and analytical systems (OLTP, OLAP), systems for management and processing huge amount of data and especially spatial data. Modern database architectures including object and post-relational models, multi-level architectures including thin clients or safety of databases are also parts of the content. The content is modified with respect to future applications in spatial databases, GIS and digital cartography.

Students have a possibility to get familiar with object oriented programming languages as C++ or Java as a part of voluntary or recommended courses.

4. EQUIPMENT

All the mentioned courses can be taught on the described level also due to a good hardware and software equipment available at the department's laboratories and computer rooms. Moreover, students have also a possibility to work out of the university building to certain extents thanks to the Site License of ESRI products that is available for Charles University and that is administrated by the Department of Applied Geoinformatics and Cartography.
It is obvious, that different vector, raster or statistic data are needed for research and pedagogical activities of the department. Furthermore, a receiving station of EUMETSAT imagery with small spatial but high temporal resolution (15 min) was established in autumn 2006. These facts have risen up a need for a new spatial data infrastructure (SDI). Effective management and accessibility of spatial data and their storage will be realized through a new data store. A map server, which will provide users with chosen spatial data, is also a part of the SDI conception.

5. CONCLUSION

The graduates of bachelor and master degree programmes with a specialization on cartography and geoinformatics have good chances to be successful in their future carrier. They can specialize on classic or digital cartography, applications of remote sensing, visualization and animation of dynamic processes in cartography, remote sensing, geography or other geosciences. They can use their knowledge in governmental institutions or local authorities where geoinformation technologies have found a wide range of applications during the last years. The graduates from the master degree study have also have also gained some basic skills for research work. Those, who found scientific work interesting, can continue in the accredited post graduate study programme Cartography and Geoinformatics.

CONTACTS

Markéta Potůčková
Charles University in Prague
Faculty of Science
Department of Applied Geoinformatics and Cartography
Albertov 6
128 43 Prague
Czech Republic
Tel. + 420 221 951 405
Fax + 420 221 951 351
Email: mpot@natur.cuni.cz
Web site: www.natur.cuni.cz/gis

Experience in the Application of E-learning Tools in Teaching

Petr SOUKUP, Pavel ŽOFKA, Czech Republic

Key words: e-learning, geoinformatics, course management system, digital maps, interactive graphics systems, computer aided design

SUMMARY

The article deals with the experience in using e-learning-based methods in the teaching of courses aimed at digital processing of graphic surveying data. It includes a profile of courses in Interactive graphics systems as they are taught at the Department of Mapping and Cartography of the Faculty of Civil Engineering, CTU in Prague. Apart from a framework overview of the course content, the article enumerates the teaching procedures applied, the topics of set assignments and the method of their assessment. Teaching texts, task assignment, instructions for their solution and continuous evaluation of students are based on a specialized course management system. The planned modifications of the teaching process are pointed out at the end of the article.

1. INTRODUCTION

E-learning has presently developed into a well-established form of teaching. Its procedures and methods implemented with the aid of suitable programming tools are subject to on-going development. The monitoring of innovations in this area and their continuous putting into teaching practice allows enhancing the effectiveness and attractiveness of teaching, both for teachers but mainly for students. The teacher's role is gradually changing with a distinct shift from routine administrative acts towards more intensive communication with students and cultivation of their own thinking. The respective procedures, observations and methods are apparently of a more general nature and can be applied in analogical teaching concepts of other subjects, too.

The primary content of the course in Interactive graphics systems is production and maintenance of digital map works. It is oriented towards using modern procedures implying the knowledge of adequate programming tools. The course in Interactive graphics systems is compulsory for students in the study branch of Geodesy and Cartography and elective in the newly opened study branch of Geoinformatics. The basic course work runs in two semesters. The first semester is devoted to a general graphics editor, while the second semester focuses on specialized surveying systems. Study possibilities are enriched with an offer of several elective courses aimed at students in higher years of study, who have already mastered the basic professional skills and are thus able to solve more complex problems in the environment of these graphics systems.

2. GENERAL GRAPHICS EDITOR

The first semester of instruction in the course in Interactive graphics systems in the study branch of Geodesy and Cartography is devoted to teaching the basics of working with a general graphics editor. For these purposes, CAD (Computer Aided Design) software MicroStation by Bentley Company [4] is used. Students step by step learn how to master basic drawing functions, take advantage of general benefits connected with drawing in CAD systems, edit drawings both in detail and en bloc, they learn how to work with reference drawings and raster files displayed in the background. Following this introduction, students become familiar with creating more complicated elements of drawings such as texts, cells, figures etc. The complexity of drawings produced during individual classes are increases with the growing students' knowledge with an underlying effort to keep to the principle of proceeding from general problems to special surveying applications.

While initial assignments represent free dimensionless painting practice, further assignments gradually move towards drawings with a defined dimension, a firmly fixed drawing setting, with demands for the data structure of the respective drawing or with students' own definitions of the attributes of individual elements (see fig. 1). Some examples of surveying applications are problems solving vectors of a transformed color raster image of a topographic map, production of cells for surveying practice or land division over a cadastral map converted into a vector format. At the end of the course, students become familiar with the possibility of using CAD software for creating three-dimensional drawings, including conversion of sample drawings and successive own practice in the generation of simple 3D objects.

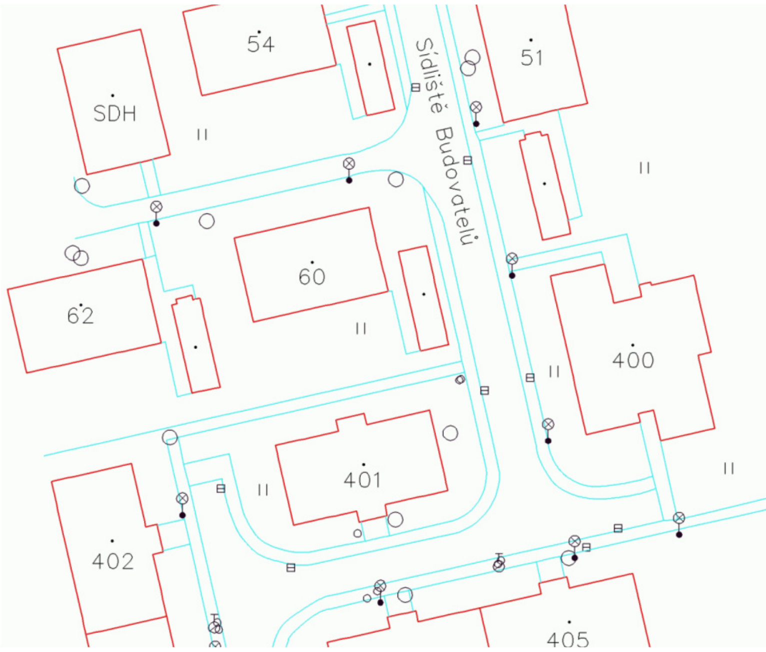


Fig. 1: MicroStation - digital thematic map

Individual assignments make up relatively independent and self-contained blocks of teaching material, and the majority of them are assigned so as to allow their elaboration within one teaching unit – two lessons (except for a more extensive assignment of a project of a family house plan, which accounts for three practical sessions). Potential individual completion of assignments outside class time is possible too, both on the faculty premises and (thanks to a simplified shareware version of the CAD system used) off the campus.

3. SPECIALIZED GRAPHICS EDITOR

Having mastered the basics of working with a general graphics editor and having obtained principal knowledge in the field of geodesy and cartography in parallel courses, students are ready for starting their work with specialized graphics systems.

3.1 KOKEŠ system

The second semester of instruction the course in Interactive graphics systems is devoted to the KOKEŠ graphics system developed by GEPRO Company [5], which, unlike general CAD systems, is deliberately oriented towards making and maintaining digital maps. The content of the practical is designed so that students may gain a coherent overview of the basic options of the KOKEŠ system, starting from the support of measured data processing via complex editing of drawings to the preparation of final cartographic outputs.

The setting of individual assignments is based on real life practical situations using actual on-site measured data or demonstration data supplied with the KOKEŠ system. For illustration see the following list of problem topics solved:

– **Geodetic grid adjustment** – calculation functions, exploitation of the GNU Gamalib module for the geodetic grid adjustment
– **Calculation of a circulation route** – basic parts of a drawing, traverse, circulation route with transition curves
– **Subscriber's line survey** – creation of a drawing using a fixed set structure (layers, types of lines, colors), Expert function
– **Special-purpose map** v**ectorizing** – raster positioning coordinates, vectorized map topology, graphic fillings of areas (see fig. 2)
– **Creation of contour line plan** – cooperation with the Atlas DMT program (digital terrain model)
– **Land division** – raster vectorizing, area subdivision, mass area calculation
– **Surveying data** – control point form, station description – schematic projection of point position

The list of problems assigned is gradually updated depending on the current development of the system and stimuli from practice. Task formulations are individualized to differentiate between individual students' assignments.

The emphasis of the teaching process is on understanding the data structure of the KOKEŠ system. Its knowledge considerably facilitates its users' understanding of the principles of more advanced work with the system. Individual editing functions of a drawing then involve apparent data manipulation.

The changeable format of graphic data of the KOKEŠ system is a text-based, publicly readily available data format. This fact is significant concerning the system's openness.
The KOKEŠ system is also used by students in the processing of a number of assignments in other subjects. These are e.g. the courses in Mapping and Land consolidation. In the course in Mapping, students produce a Digital cadastral map of the territory in question, from field book calculations to the printout of the map output. In the course in Land consolidation students can use a specialized PROLAND superstructure developed expressly for the purposes of designing complex land consolidation projects. The KOKEŠ system is also widely applied in field work in Mapping where the topographic map original could be hardly created without the help of the KOKEŠ and Atlas programs.

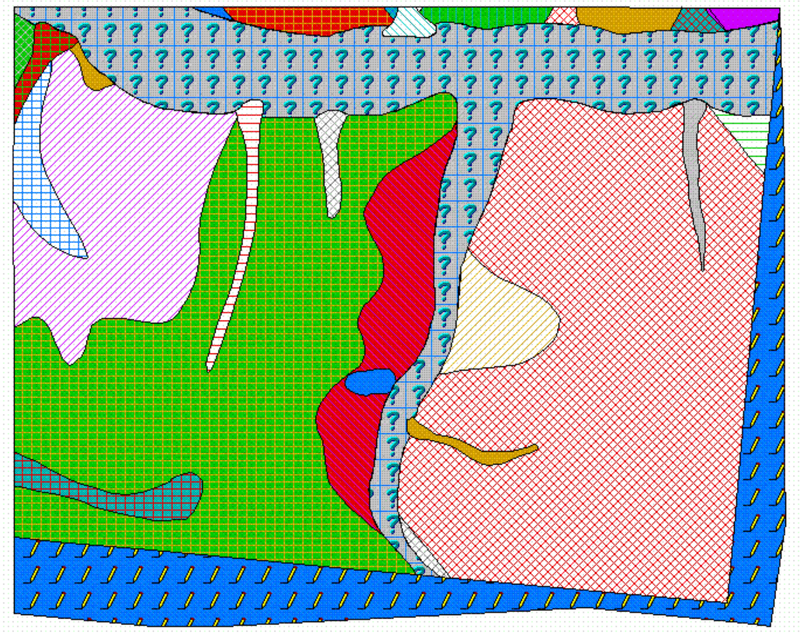


Fig. 2: KOKEŠ - vectorization of geological map

The KOKEŠ graphics system as a universal tool for working with graphic data provides an excellent environment for the implementation of students' works and projects. In this respect, the possibility of creating one’s own program extensions in the KOKEŠ-Basic programming language must be mentioned. During the last several years, a number of diploma projects have been worked out in this way including e.g. a module for the automated generation of a longitudinal section and transverse cross sections of water courses or a module for the conversion of coordinates of points between various cartographic projections.
All possibilities of the system can be used to the full extent, both in teaching and in the Bachelor and Master diploma’s projects thanks to excellent many-year cooperation with the system’s authors.

3.2 MISYS and MISYS-WEB

The teaching process also makes students familiar with the MISYS programming system. It is a superstructure above the KOKEŠ system designed primarily for handling the real estate register data. It contains advanced functions for searching information filed in written cadastral documents. Students appreciate mainly the close two-way interconnection of the topographic base with the corresponding written extracts. The items of extracts (parcels, buildings) can be looked up on the map, both individually and in bulk, and, analogically, through the identification of map elements the extracts of data filed on them in the real estate register database can be obtained.

Instruction also presents extending modules to the MISYS system, which allow registration of nearly any spatially localized subjects of interest within the territory (see fig. 3). Each object can be assigned information in a wide range of formats (text, image, animation, video). Object search according to a number of criteria and the interconnections of the objects with the system's graphical part is a must. In this phase, instruction touches upon the area of geographic information systems.

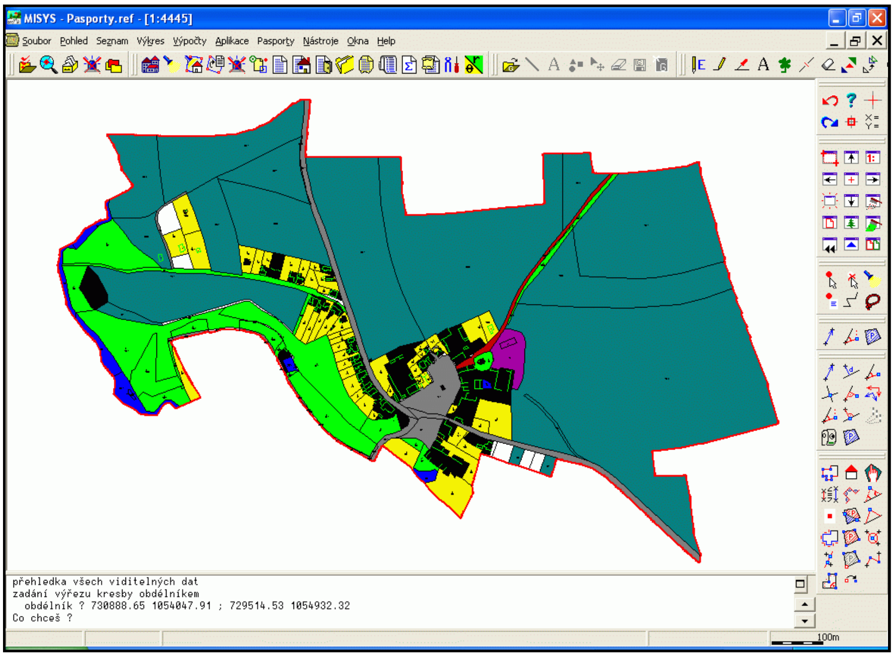


Fig. 3: MISYS - visualization of database entries

Students learn how to practically control specific GIS. Deeper theoretic background and further practical skills in these problems are obtained in specialized follow-up courses.
Unlike the MISYS system, which runs on a personal computer using locally stored data, there presently exists its modification called MISYS-WEB, which serves for working with geographical data located on a remote server of the Internet network. Sharing centrally stored and managed data through the Internet represents an efficient data model. All system and data installations are made on the part of the server, while the user's part requires only a standard web page browser fitted with a general, readily accessible extension. As compared to the MISYS system, MISYS-WEB possesses a reduced scope of functions allowing data viewing without editing.

The MISYS-WEB system is presented to students on several data servers with public access, which do not require a verification of the user's identity (see fig. 4). Accessible displays include e.g. the use of this application as an information system of a municipality, a map portal of a well-known Czech cartographic company or a collection of cadastral maps. Individual samples contain specific functions designed for the respective purposes.

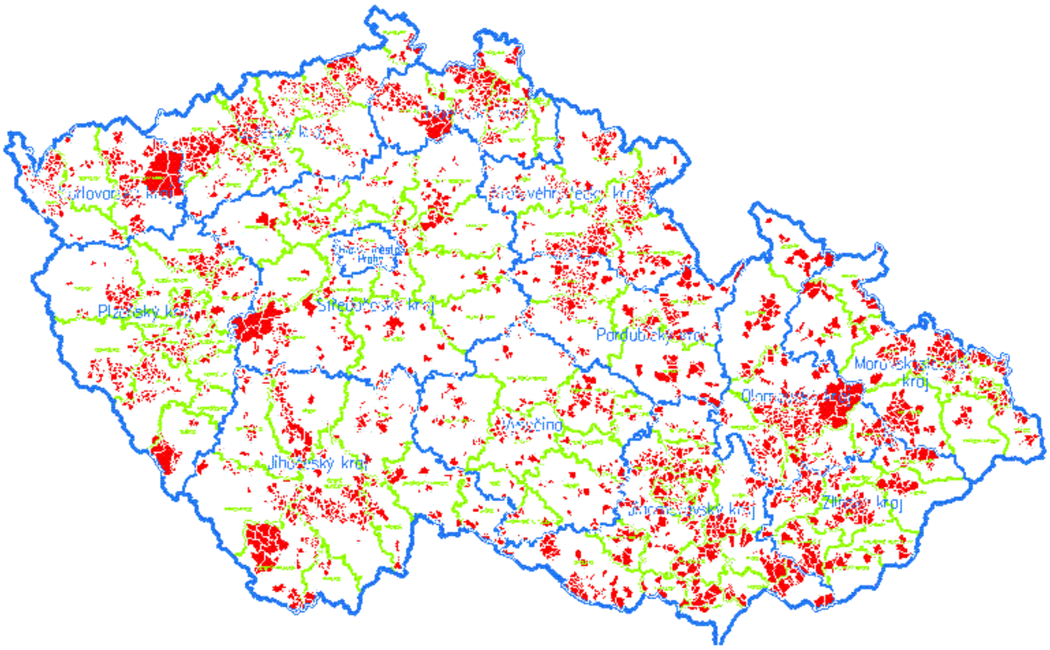


Fig. 4: MISYS-WEB - digital cadastral map in the CR

4. SPECIALIZED MODULES

Starting from the forthcoming academic year, instruction in the course in Interactive graphics systems will be extended by adding another semester aimed at students specialized in technical surveying. The material content of the new semester encompasses areas which were, for time or pedagogic reasons, left aside in the previous semesters of instruction. The course is designed for students of higher years of study, who have already gained a wider scope of branch-oriented knowledge and so the teaching can be oriented to working out more demanding tasks:

– **Digital terrain model** – design and presentation of a DTM based on ZABAGED (basic geographic database) using the interconnection of the KOKEŠ and Atlas DMT systems. The resulting terrain model will be interactively presented on the website.
– **KOKEŠ-Basic** – getting to know the integrated development environment of the KOKEŠ system and its application for the creation of new user functions. Here, students implement their previously gained programming knowledge in the field of attractive interactive graphics.
– **MISYS** – application of the MISYS system for the generation of a module (passport) serving for the monitoring of selected objects of interest filed in the topographic base.
– **Geometric plan** – elaboration of a simple geometric plan in a locality with a digital cadastral map using the GEPLAN superstructure.
– Land consolidation – processing of selected sections of a complex land consolidation design using the PROLAND superstructure (implementation of owners' demands in compliance with legislative criteria).

5. FORM OF TEACHING

Instruction in all above-mentioned courses is held in computer laboratories of the branch of Geodesy and Cartography in groups composed of maximum 20 students. The number of PCs in the classrooms allows for individual work of students. Students individually work out their assignments with the assistance of the teaching staff and supporting web pages.

Instruction based on applications for personal computers (as is the case of the above-mentioned interactive graphics systems) is able to exploit modern tools offered by the present-day development of information technologies in this area. In this respect, so-called e-learning comes to mind, which brings new exciting possibilities into teaching [1].

5.1 E-learning at CTU

The teaching process involves a number of necessary administrative acts which are both considerably time consuming and take up the limited capacity of teachers. These are activities such as making records of students' study activities, setting and correcting assignments, setting and correcting students' knowledge tests, electronic communication with students etc. Hand in hand with the advances in information technologies, there is a growing trend towards providing students with more freedom for study, both in time and space. The fulfillment of all these aspects of modern instruction is aided by program tools often abbreviated as CMS (Course Management System).

In our opinion, until recently the CTU lacked a clear concept in the course management system area. The preferred system was changed several times. The present-day situation concerning further development of e-learning at our university is starting to take more distinct features. The web portal [6] was established whose main target is to facilitate access to courses and other professional sources available through the Internet for the CTU students and teachers. At the same time, the portal should serve for the promotion of the CTU with the public providing an all-round survey of the development of e-learning at our university. The portal stores not only teaching texts, but all additional teaching materials in a wide scope of formats (powerpoint presentations, collected problems, tests, animations, virtual and real-life experiments, sound and visual recordings, programs etc). Any one can send the portal administrators data on the university teaching materials for the purpose of their saving in a database.

The CTU presently prefers the use of two course management systems. They are the licensed Class Server system and a newly available Moodle system.

5.2 Moodle system

A prospective alternative of further progress in the field of e-learning seems a possibility of using course management systems developed and distributed on the basis of the GNU license. One of the best known representatives of this category is the Moodle system (Modular Object-Oriented Dynamic Learning Environment) [7], which is thus made available without any license fees, including source codes.

The teaching of interactive graphics systems is oriented, in particular, on the Moodle system, which finds implementation at many other universities as well, both abroad and currently also in our country. The use of this system has proved beneficial resulting in time savings in several areas [2, 8].

5.2.1 Setting and correcting assignments

Administrative chores connected with the assessment of individual assignments by all means represent the heaviest time load for the teachers of the respective type of courses. Due to the number of students and the fact that each submitted result must be individually corrected and assessed, each attempt to simplify this activity is most welcomed. The Moodle system significantly facilitates the required routine work. It allows setting deadlines for submitting assignments, recording the time of their submittal, the assessment of assignments can be complemented with a commentary which is automatically sent to the student via e-mail. The exploitation of the Moodle system also presents advantages for students. They may hand in their assignments from any place via the web interface and have a perfect record of all submitted assignments and their assessment. This method of publishing the results of their assignments implies more privacy for students as compared to putting the results on public web pages.

5.2.2 Students' accounts

For active participation in the teaching courses managed by the Moodle system, all students must possess their own created accounts. A self-service system of opening students’ accounts is possible but leads to a lack of systematic and clear arrangement of the accounts thus created. On the other hand, manual opening of the accounts by teachers is also possible, but rather time consuming and with greater numbers of students and courses practically unfeasible. Fortunately, the accounts can also be created in an automated way. The basis is a text file containing all necessary information which is filed in the CTU information system called KOS (Student Components). Each teacher is entitled to create this file with information on students registered for the courses they teach. The necessary conversion of this file’s format to meet the demands of the Moodle system is done by the resulting program itself so that the creation of students’ accounts is basically carried out in a fully automated way.

5.3 Testing of students

Testing students is considered to be a very important part of the teaching process [3]. The results of tests convey information on study interesting both for teachers and students. For testing purposes we use our own program system working in the web browser’s environment and allowing a variable setting of the parameters of tests and the methods of their assessment. The system includes a synoptic list of the results of tests, including their statistical analyses and an option of reassessment of the results in keeping with a modified classification scale. The program is subject to an on-going development and improvement to meet the teachers’ requirements. The results of tests presently form an inseparable part of the overall classification of our students.

5.4 Teaching evaluation survey

At the end of the semester, students are provided with a possibility of an anonymous evaluation of the content, quality level and benefits of completed instruction. Apart from formulated questions, the questionnaires contain space for free expression of any students' opinions. The survey results provide us with highly valuable feedback on the students' evaluation of instruction. Although their comments sound mostly very positive, we always try to listen to potential critical remarks in an effort to improve instruction in the future. The survey confirms that students appreciate mainly responsiveness, willingness to discuss problems and the overall class atmosphere, i.e. aspects that electronic courses prepared with the best intention on their own can hardly fully replace. In this respect, the teacher's role is irreplaceable.

6. PLANS FOR FUTURE

Although the existing method of instruction in the above-mentioned course in Interactive graphics systems applies modern and accessible tools, other changes and extensions are planned to be introduced in the near future. These changes are both in the form of teaching materials used and in the update of the program modules supporting the administrative component of instruction with the aim of enhancing mutual integration. The course content follows the current trend with an effort to strengthen the mutual links between individual assignments to transform them into separate projects.

6.1 Multimedia teaching materials

The existing study materials in the electronic format cover the whole complex of the subject matter taught. Their present-day form is predominantly a text format fitted with static images. In order to raise the attractiveness of the form of study materials, we are planning to produce a set of animations with sound, which would vividly depict the more difficult steps of working with graphics systems. At present, these processes are projected by teachers on the screen using a data projector, which is definitely a highly vivid presentation method, but does not give the student a chance of easy repetitive viewing. Animations, however, will eliminate this drawback. This will make study more attractive for students with enhanced efficiency and some aspects of distant learning.

6.2 Integration of teaching tools

A low-level interconnection of the used program modules often causes complications in their simultaneous exploitation in the teaching process. In particular, the applications designed for testing students' knowledge and for evaluating the teaching process are presently separate programs that have been developed on our own and that are not part of the Moodle system. Their results, therefore, are difficult to transfer into the other data sets of this system. We would like to integrate the testing and survey software into the environment of the Moodle system so that their resulting outputs are an integral part of the Moodle system's data space.

7. CONCLUSION

E-learning as well as interactive graphics systems are going through a rapid development. E-learning tools are presently commonly used at numerous schools as a standard teaching component. In the field of graphics systems, there is an increasingly growing role of 3D modeling or automation of complex editing or calculation procedures in general. To this end, the setting of individual assignments is also continuously modified and updated to match the current development of the respective interactive systems and procedures applied in practice.
We believe that the presented problems have good prospects for the future and their teaching brings students knowledge that will considerably contribute to their practical professional skills.

REFERENCES

[1] Uhomoibhi J. O.: Implementation of E-Learning in Engineering Education: Evaluation of Students Skills and Learning Approaches, International Conference on Engineering Education, 2005, Gliwice, Poland, Volume 1, pp. 738-743.ISSN 1562-3580
[2] Soukup, P.: Course Management Systems in Moodle System. In: Sborník referátů (CD ROM): Geoinformatics CTU 2006, CTU Prague. Faculty of Civil Engineering, 12.5.2006, pp. 152-157. ISSN 1802-2669
[3] Soukup, P. (2004): E-learning and Checking of Study Effectiveness by Testing. In: Proceedings of Conference ICETA 2004: Information and Telecommunications Technologies in Education, Košice, Slovak Republic, 16.9. - 18.9.2004, pp. 371-375, ISBN 80-89066-85-2
[4] http://www.bentley.com
[5] http://www.gepro.cz
[6] http://courseware.cvut.cz
[7] http://moodle.org
[8] http://geo2.fsv.cvut.cz/kurzy

BIOGRAPHICAL NOTES

Petr Soukup – In 1987 – 1991 he was first engaged as a researcher in the Prague Geodetic and Cartographic Company (Centre of remote Earth investigation), later as a surveyor and programming analyst. Since 1991 he has worked at the Department of Mapping and Cartography of the Faculty of Civil Engineering, CTU in Prague as a senior lecturer specialized in the problems of digital processing of surveying data.

Pavel Žofka – In 1987 – 1991 he worked in the section of photogrammetry in Geodézie Praha Company, in 1991 – 1993 as a surveyor in a private firm, in 1993 – 1994 as a researcher in the Prague Research Institute of Geodesy, Topography and Cartography. Since 1995 he has been a part-time staff member and since 2003 a senior lecturer at the Department of Surveying and Land Consolidation of the Faculty of Civil Engineering, CTU in Prague specialized in teaching interactive graphics systems.

CONTACTS

Ing. Petr Soukup, Ph.D.
Czech Technical University in Prague
Faculty of Civil Engineering
Department of Mapping and Cartography
166 29, Thákurova 7
Prague 6
CZECH REPUBLIC
Tel. + (420) 224 354651
Fax + (420) 224 355 419
Email: soukup@fsv.cvut.cz
Web site: http://gama.fsv.cvut.cz/wiki/index.php/Ing._Petr_Soukup,_Ph.D.

Ing. Pavel Žofka
Czech Technical University in Prague
Faculty of Civil Engineering
Department of Geodesy and Land Consolidation
166 29, Thákurova 7
Prague 6
CZECH REPUBLIC
Tel. + (420) 224 354 662
Fax + (420) 224 355 419
Email: zofka@fsv.cvut.cz
Web site: http://slon.fsv.cvut.cz/~zofka/

A Research-based Curriculum for Cadastral Studies

Erik STUBKJÆR, Denmark

Key words: cadastral studies, cadastre, curriculum, land administration, study program

SUMMARY

In the 'Vision on the function of Cadastre and Land Registry in Europe', the national institutions in charge of cadastre and land registry are prompted to 'promote the educational institutions that are providing the influx of young professionals and [to be] in continuous contact with these institutions to guarantee the permanent adjustment of their training programs' (Vision version May 22, 2006). From the university side, such engagement must indeed be welcomed. The paper addresses this challenge through the indication of pertinent fields of research and the suggestion of relevant components of curricula or study programs.

University education has for about two centuries been research-based. In the ideal type situation, this means that teaching is based on knowledge which is proven through experiments. This praxis of experimentation has a long tradition within geodesy, land surveying and the disciplines of modern mapping technologies. However, the 'soft' disciplines of planning, cadastre, and land law have difficulties in achieving the same degree of scientific rigor. This may be related to the fact that these disciplines were introduced fairly late and was not given much support at the predominant type of educational institution, the technical university. Furthermore, during the last decades a post-modern conception of research influenced the mentioned social sciences, claiming knowledge to be context bound. The implication of this view is that adherence to the tradition of accumulation of general knowledge would be futile. This is bad news to management of cadastral and land registry organizations, assuming that the management want to base their decisions on knowledge rather than opinions and trends. The paper argues that management should alley with universities to provide the resources needed to address such intricate issues, even if a pay of in the short run is not evident.

1. INTRODUCTION

The notion of 'big science' is conventionally related to the production of huge rockets, high-energy accelerators, nuclear research reactors, and similar (Weinberg, 1961). However, the notion of 'big science' makes sense also within the field of land administration systems when considering the investments provided by, e.g. the World Bank for land reforms and similar measures. Although such projects are extraordinary, compared to mundane recording of real property, these large-scale land reform projects are indeed of importance, also for European agencies and universities. This is because the World Bank projects may be interpreted as large scale experiments which test whether the prevailing knowledge on land titling issues are sufficient. A problem with this endeavor is that the boundary conditions of the experiments are hard to control. Never the less, research in development projects of the last decade revealed that a focus only on the market in individually owned land is a too restricted approach (Fortin, 2005). This position is supported by research in development economics. So called heterodox economists maintain the crucial role of government in bringing about wealth for its citizens, as the market alone will not achieve this. To illustrate this by example: After the United States got independence from Britain, it set up a protection scheme of tariffs and bans on imports, to allow 'infant industries' to become internationally competitive. In the 19^{th} century, American tariffs were among the highest in the world, and it was only after World War II that the US significantly liberalized its trade and took up the cause of free trade (Jomo, Reinert (2005) pages 10f and 100f with reference to Chang, 2002).

Turning back to the European setting, the above suggest that in order to contribute towards social and economic development, land administration agencies, universities, and professional organizations should prioritize securing rights in real property also for those at the edges of the established market. An active effort to support all members of a community is needed to balance individual autonomy, and the state and its branches is the major instrument for that. In fact, the cadastre emerged precisely in those kingdoms and countries where statesmen acted out to bring available resources to better use: population through general education and health measures, industry through roads and other infrastructure, and not least through improved public administration. The tendency, during the last decades, to call for 'less state, and more market' has supported the vocal demands of market players and their parrots. The position is taken here that such praise of the market is largely unwarranted. "The 'invisible hand' of the market mechanism requires a highly visible hand of enabling political regulation in order to work properly" (Sørensen, 2001, p. 6). Consequently, a more balanced view of land administration issues should be considered within national policy lines, cf. the Eurogeographics/ PCC Vision Statement: Cadastre and Land Registration in Europe 2012, presented in November 2006 (Laarakker, 2006).

Departing from the above stated worldview, the paper proposes components of study programmes which in the medium term should assist in complying with the needs of the European national societies. Cadastres developed in European before the modern university compartmentalized knowledge into disciplines like law, economics, and political science. Therefore, cadastral studies have to be multi-disciplinary in order to re-integrate the knowledge needed for sustainable recording of rights in land and further attributes of immobile assets.

The study program and its target group are outlined in section 2. The following section 3 comprises of subsections which each address a discipline. Knowledge from these disciplines were lectured during an ad hoc study programme in Autumn 2006. In section 4, experiences on students' mobility and acquisition of the material are reported. A conclusion closes the paper.

2. A LAND ADMINISTRATION STUDY PROGRAMME OF EUROPEAN SCOPE

2.1 The need for advanced master and doctoral studies and the target groups

The Work Plan of FIG Commission 7 – Cadastre and Land Management, surveys an impressive array of tasks which face cadastral agencies and their staff in the coming years.

The knowledge needed to address these tasks has to be extracted from a number of disciplines, mostly related to the social sciences.

The present surveying programmes of European universities does include topics of a social science nature, including land use planning and cadastral law. Furthermore, the management of geographical information - be it in central or local government, or in private companies or bodies of civil society - needs a good understanding of organizational and legal issues, and these social science issues may be addressed in existing geoinformatics courses as well. Thus, for most geodesy students, the national teaching in the mentioned fields is sufficient.

However, some students would like to focus on the social and managerial aspects of the surveying trade and for those students more advanced programmes are needed. This is especially the case, if they consider continuing their studies with the objective of attaining a PhD.

The need for specialists with better understanding of institutional and related issues is obvious at mapping and cadastral agencies. Furthermore, consulting companies of European scope are becoming more visible and they require an understanding of social and institutional issues which is not restricted by the practise of the candidate's home country, but rather is scientifically based. The same holds true for positions within the European Commission and bodies like EuroGeographics and CLGE who mediate between Commission departments and national organisations. Finally, the ease of long distance communication and transportation has made it feasible to spend some years abroad in development organisations, NGOs, or similar. Also here, advanced courses are needed to reflect the national knowledge and practise in a scientific and international context.

Although the needs thus may be firmly established, the actual demand of graduates is not large enough to provide such formal education in each of the small and medium-sized countries of Europe. Therefore, it is appropriate that a division of work takes place among universities, so that each specialise in the courses and other study elements which fit their specific strengths.

2.2 The structure of study programmes; Erasmus Mundus

Within Europe, study programmes with a deeper social science approach have emerged in countries which support cooperation schemes with developing countries. An inventory of such programmes is provided in (Stubkjær, 2006) and hence not iterated here. However, such study programmes hardly meet the demand outlined above, partly because access is restricted, partly because the programmes are full master programmes. Of course, European universities may compete head-on to attract students to their master programmes. A more considered approach would be to establish a co-operation among a home university, where the student takes the MSc. Degree, and one or more hosting university, which offers supplementary, advanced study element.

Co-operation among European and other universities is supported by the Erasmus Mundus programme of the EU. The academic recognition of a period of study abroad is within the discretion of the home university, which may use instruments available for such recognition, including the ECTS rating scheme and the Europass Diploma Supplement (EUinfo, 20067). Individual study visits may be supported by the Erasmus scheme. This arrangement is managed by the home university.

The main instrument for co-operation is Erasmus Mundus Masters Courses. Existing programmes with some bearing on the domain addressed here include the following, which are found within the two categories: Geography, earth and environmental studies, or Engineering, technology, respectively.

- 2004 IMRD: International Master of Science in Rural Development (Ghent Uni, B)
- 2005 GEM: Geo-information Science and Earth Observation for Environmental Modelling and Management (ITC, NL)
- 2007 Master of Science in Geospatial Technologies (Münster, D)
- 2007 JEMES - Joint European Master Programme in Environmental Studies (Hamburg TU)
- 2007 COMEM: Coastal and Marine Engineering and Management (TU Delft, NL)

The year indicates the year of granting. The university mentioned is the coordinating university, as three or more European universities have to set up a consortium. Consortium partners have to agree on a joint master's programme, often lasting two years. Students will study at two or more universities. Find details at EuroInfo (20067).

3. RESEARCH TASKS AND CORRESPONDING STUDY ELEMENTS

3.1 Overview

Research tasks are specified in the Work Plan for FIG Commission 7, as mentioned above, but appears also from the activities and documents of EuroGeographics, especially its Expert group on Cadastre and Land Registry, as well as the Permanent Committee on Cadastre in the European Union, and the WPLA, Working Party on Land Administration within the Division of Environment, Housing and Land Management of UNECE, the United Nations Economic Commission for Europe. As for international research needs, the activities and documents of the Commission on Legal Empowerment of the Poor of the UNDP, and the Centre for Property Rights and Development of the Norwegian Mapping and Cadastre Agency, may serve as a reference.

Faculties and Study Boards of European universities have to face the challenge posed by the research needs of these bodies. If the capacities of their staff and the content of their study programmes are not aligned with the stated needs, the research tasks will be addressed by other parties and the development potential of the surveying profession will diminish.

In the following, a survey of subjects is presented which might be needed in future study programmes. The list is indicative only and references to literature are largely omitted. It is organised along the lines of traditional disciplines, partly because knowledge have been accumulated within these disciplines for a century or so, partly because it might suggest cooperation with staff from these disciplines and the related departments.

3.2 Law

The very notion of property rights is based in private and public law which is expressed in national language. The recording and commenting of pertinent laws and ordinances, as well as collection of court and administrative rulings are traditional elements of master programmes.

New types of research and teaching regard the impact of EU norms and rulings on the national legal system. Moreover, the European University Institute in Florence frames a European Private Law Forum has initiated a project which calls for attention: 'Real Property Law and Procedure in the European Union'. The preparation of comparative, national reports of the current legal situations is in process. The reports will focus on conveyancing, mortgaging and related questions of land registration as well as European law influences. The law professors related to surveying departments should ally to complete the process and participate in the further development.

The public access to data and the protection of privacy is an issue of importance to mapping and cadastral agencies. This includes research in pertinent thresholds for geostatistics. Master courses should provide sufficient knowledge on these issues, also in order to provide a basis for PhD research. The same holds for immaterial property rights to geospatial information.

3.3 Sociology, Political Science, Public Administration

Cooperation among national bodies responsible for property register and the implementation of INSPIRE are urgent issues for mapping and cadastral agencies. While these issues include legal and technical aspects, the key issues regard organisations, their internal functioning and the interplay among organisations. The notion of organisation here refers to the general concept which comprises a ministry, an agency, a company, and an association, that is: any unit of cooperation among humans with stated name, purpose, and decision rules.

The decision hierarchy within an organisation complements the individual activities of market players. *Hierarchy* and *market* appears to be mediated by *networks* among organisations; the concepts thus refer to three complementary organization principles. Differently from what is conventionally taught, statutory acts are not primarily the outcome of public debates in the news, deliberations among and within political parties, and Parliamentary activities. Rather, what is called *policy issue networks* are the breeding place for new rules and revised allocation of competencies and resources.
Master programmes need to provide the graduates with skills to identify and navigate within these policy networks and to further the matters of the agency concerned. Fortunately, the need to adopt these skills is realized also by other branches of technical faculties. Airports or harbours are technical constructs like national property registers, but their proper functioning depend on an understanding of the social environment of the technical part. Consequently, a leading faculty like Technology, Policy and Management of TU Delft is offering courses in for example Inter-organisational decision making, and Designing multi-actor systems. This practice needs to be exteded to the geospatial domain.

3.4 Economics

The New Institutional Economics, primarily related to the name of Douglass North, was introduced to the FIG community by Sevatdal (1999, 2002), Zevenbergen (1999), and van der Molen (2001), among others. New Institutional Economics provided the theoretical base for the research action ‘Modelling Real Property Transactions’, which attained support from ESF/COST during 2001-2005 (Stubkjær, 2002; COST, 2006).

This theoretical approach support the assessment of transaction costs, that is the costs related to the purchase of immobile property and related, e.g. cadastral processes. It thus provides a frame for comparison of administrative effectiveness across national practices in Europe. Also, it provides a sound basis for assessing the structure of fees and financing schemes. Moreover, it expresses research outcomes within the framework in which competition authorities operate. By supporting research in this field, mapping and cadastral agencies will expand their potential to comply with expectations of the national and EU competition authorities.

Real property assessment should also be researched and lectured at some depth within a few European departments. Research issues include the modeling needed to produce reasonably accurate taxation values for the stock of property units on the basis of available sales data. Due to frictions among involved public and private bodies, available sales data are often not used effectively. This important research area is, however, best addressed within the theoretical context of sociology and public administration.

3.5 Technology

Mapping and positioning technology, as well as computer and web technology is mentioned mostly for reason of completeness. Before the present age of automation, mathematics played a more prominent role in the study programmes. If this discipline is not replaced by other study elements which demand abstract reasoning, the surveying programmes might risk their credibility among other disciplines of the technical faculties.

3.6 Cadastre as a subfield of informatics

Real estate units and identifiers, rights and interests, the Core Cadastral Domain Model, the cadastral parcel in INSPIRE and other geospatial infrastructures, the 3D cadastre, are all issues which should be and mostly are deeply covered by study programmes and research.
These issues demand a strong adoption of methodologies from informatics, but it would be mistaken to restrict cadastral studies to the informatics aspect. The message of the preceding sections is that cadastral studies needs the integration of the disciplines covered.

3.7 Methodology

Scientific methodology is an important but also complicated field which cannot be adequately treated in the present context. The following outlines the issue by way of example; for a more classical approach see e.g. Silva, 2001.

FIG Commission 7 Work Plans include the 3D cadastre as an important research issue. The issue is also highlighted in communications to international organizations (Enemark, 2006). This call for research has been answered, primarily through the book by (Stoter, Oosterom, 2006), but also through a number of other publications, including workshop proceedings (e.g. Oosterom, et al., 2001). The complexity of the field may be structured along the levels of social analysis, proposed by O. Williamson (2000) and similar by Paul van der Molen (2001).

A further structuring of the research questions along the lines of established disciplines could assist in obtaining more valid conclusions. For example, the potential of technology can be investigated from a more 'pure' point of view, in a kind of laboratory situation, or it can be investigated with focus on real-world processes and systems. The latter has the consequence that local practices influence the outcome of the investigations, which may ease the local decision process, but hamper the relevance for the external, international audience.

The potential of new technology has to be brought to the attention of decision centers of the national and international society, but securing rights for those at the edges of the established market is also a legitimate research objective. Perhaps, more emphasis should be devoted towards the analysis of needs: Shall priority be given to the needs of the system user (predominantly the cadastral agency itself) or to the end-users of the system? The answering of such questions may eventually evolve into a reasoned priority scheme for cadastral development.

This section set out to remind university faculties and study boards of development needs. The chapter listed a set of suggestions for enhancement of existing study elements and adoption of new. No specific references to literature were provided, as this can better be performed through a joint effort.

4. EVALUATION OF AN AD HOC SEMESTER PROGRAMME

The purpose and content of the semester study programme 'Land Management and Cadastral Development, focusing on Real Estate Taxation' was outlined in (Stubkjær, 2006, page 9-12). The study director approved a proposal which fitted within the rather open ninth semester of the established (Danish) M.Sc. Programme in Surveying. The study programme was presented on the web (SemesterProgramme, 2006) and the website of the Study Board briefly mentioned the programme, but else no advertising efforts were made.

Two students reflected on the proposal, a MSc student and a PhD student. In both cases, their study visit was financially supported by Erasmus Mundus scholarships. Both were enrolled as ninth term students at the surveying programme and at the end of the semester passed examinations according to the formal rules and practices of the Danish surveying programme. The study director acted as the examiner. The university has established a formal quality control system which includes forms in English language (Kvalitetshåndbog); accordingly, the visiting students reported on their experiences. The following draws on these evaluations.

The study was to be performed largely as an independent study, with a monthly conversation with the supervisor. Therefore, the semester programme described for every month a set of study elements and deliverables. The elements were not compulsory; the visiting student could replace elements with other study activities, or change the proposed weight of the elements. For example, both students participated in some related courses which were lectured in English. To manage this, a specific study plan was set up during the first month. In both cases, this plan was again revised around November and then used as a backdrop for the examination. The study plans were brought to the attention of the visiting students' home supervisor, and in one case, the home supervisor influenced the weighting of subjects studied. The detailed list of study elements thus functioned more as a rescue tool, e.g. in case of illness of the supervisor, rather than a binding norm. The real norm was set by the students, who in dialogue with the supervisor(s) directed their own learning path, an option warmly commended by both students.

Both students learned from comparing the property registers of their home country with the Danish registers. They also reflected on how a socio-technical system, like cadastre and other property registers used for property taxation, were established or transformed. The bulk of activities addressed these issues, which were also at the focus of examinations. However, as this content appears from the publicly available study programme, no further mentioning is needed.

The individual steps in the scientific formation process highlighted very different elements of the proposed study programme. The element: "Identify and select fragments of your home country's fiction literature, which describe the relation of people to land, soil, and ownership" meant a lot to one student, who soaked more in this subject than anticipated. Such study hardly improves your technical skills, but carrying the burden of unsolved questions may eventually emerge as new insights and therefore the chosen priority of this subject was confirmed. – The other student was more eager to "reason on causes of change of [selected] social components of the domain of land management", including the reflection of European traditions in a globalized world.

The idea of focusing on definitions worked well for both students, who among others developed their source criticism through this work. It was not explicitly requested that the list of definitions should be updated and/or revised during the semester and none did so. Although definition work is a time consuming job, it is also scientifically rewarding and could support more coherence among the rather freely elected subjects of the semester study.

The students were invited to set up their own website. Both managed to do so without specific teaching. Drafts and working papers were exchanged via email and provided a basis for email dialogues and the monthly conversations with supervisor. This worked well, but the web tools could well be introduced at the very start and used in a more structured way during the semester. The easy Internet access and the "very helpful personnel of the University" were acclaimed.

The section of related courses was hampered by outdated study guides and semester plans not in accordance with current plans. Moreover, descriptions of some educational programmes "were very vague and poor". It was proposed that name and the email address of the various semester coordinators be easily accessible on the web. Also, the lack of English classes for foreign students was considered a drawback, but both welcomed the opportunity to apply their language skills. For the PhD student a meeting was mediated with a property valuation expert of the government.

Concluding, it seems that all parties benefited from the learning experience and that it can be used as the basis for attracting more visiting students.

5. CONCLUSION

Assuming that management of cadastral and land registry organizations want to base their decisions on knowledge rather than opinions and trends, the paper has related their research needs to available knowledge within a number of social science disciplines. Faculties and Study Boards of European universities were reminded of the challenge posed by the research needs of cadastral and land registry organizations. If the capacities of staff and the content of study programmes are not aligned with the stated research needs, the research tasks will be addressed by other parties and the development potential of the surveying profession will diminish.

A more promising scenario is proposed through the reference to the development of joint study programmes and to the support by EU schemes, Erasmus Mundus in particular. Agency management should alley with university staff to provide the resources needed for research, even if a pay of in the short run is not evident.

REFERENCES

Chang, Ha-Joon (2002) Kicking Away the Ladder – Development Strategy in Historical Perspective. London, Anthem Press.

COST (2006) Final Evaluation Report of COST Action G9 'Modelling Real Property Transactions' 2001-2005. Approved by COST Domain Committee Individuals, Societies, Cultures and Health, November 2006. 35 p.
http://www.cost.esf.org/index.php?id=439 > Download Final Report

Enemark, Stig (2006) The Integration of Natural and Built Environment Data – The Experience of Europe with a Focus on Denmark. Invited Paper. Submitted by International Federation of Surveyors (FIG). Seventeenth United Nations Regional Cartographic Conference for Asia and the Pacific, Bangkok, 18-22 September 2006
http://unstats.un.org/unsd/geoinfo/17thunrccapIP40.pdf

EUinfo () ECTS - European Credit Transfer and Accumulation System
http://ec.europa.eu/education/programmes/socrates/ects/index_en.html
EUROPASS for better transparency of qualifications and skills
http://ec.europa.eu/education/programmes/europass/index_en.html
Erasmus Mundus, incl. Erasmus Mundus Masters Course
http://ec.europa.eu/education/programmes/mundus/index_en.html

Fortin, Elizabeth (2005) Reforming Land Rights: The World Bank and the Globalisation of Agriculture. Social and Legal Studies 14 (2) 147-177. Available at http://www.oxfam.org.uk/what_we_do/issues/livelihoods/landrights/downloads/reforming_land_rights_wb_agric.rtf

Jomo, K.S; Erik S. Reinert (Eds) (2005) The Origins of Economic Development Economics. London, Zed Books.

Kvalitetshåndbog () Semester evaluation - summary; Supervisor evaluation
http://www.lsn.aau.dk/Semester%20evaluation%20-%20summary.doc
http://www.lsn.aau.dk/Supervisor%20evaluation.doc

Laarakker, Peter (2006) Cadastre and Land Registration in Europe 2012 Vision Statement. Presented at PCC Helsinki, November 30, 2006
http://www.eurogeographics.org/eng/documents/Laarakker_vision_001.pdf (2007-03-20)

van der Molen, Paul (2001) Institutional aspects of 3D cadastres. Page 53-65 in Oosterom, P.J.M van, J.E. Stoter and E.M. Fendel (eds.) (2001): Proceedings of the international workshop on 3D-Cadastres. Delft, November 28-30, 2001.

van Oosterom, P.J.M., Stoter, J.E. and Fendel, E.M. (2001) Registration of properties in strata: proceedings of an international workshop on 3D cadastres : Delft, November 28 - 30, 2001. Denmark, International Federation of Surveyors (FIG), 2001. 322 p. ISBN: 87-90907-15-9.

Semester Programme (2006) Land Management and Cadastral Development, focusing on Real Estate Taxation - An ad hoc Study Programme for Autumn Semester 2006 at Department of Development and Planning, Aalborg University
http://www.plan.aau.dk/~est/Undervisning/LMCDtaxation2006/LMCDAutumn2006.html (2007-03-20)

Silva, Maria Augusta and Stubkjær, Erik (2002) A review of methodologies used in research on cadastral development. Computers, Environment and Urban Systems. 26 (5) 403-423.

Stoter, J.E. and van Oosterom, P.J.M. (2006) 3D Cadastre in an international context : legal, organizational and technological aspects. Boca Raton, Taylor & Francis, CRC, 2006. 323 p. ISBN: 0-8493-3932-4.

Stubkjær, Erik (2006) Modelling Real Estate Business for Governance and Learning. FIG Workshop on eGovernance, Knowledge Management and eLearning. Budapest, Hungary, 27-29 April, 2006
http://www.fig.hu/papers/225.pdf (2007-03-20)

Sørensen, Georg (2001) Muddy Waters: The Debate on State, Markets, and Globalisation. Paper, presented at International Studies Association's Hong Kong Convention of International Studies, 26-28 July 2001. 32 p.
http://www.isanet.org/archive/sorensen.doc (2007-03-20)

Weinberg, Alvin (1961) Impact of Large-Scale Science on the United States *Science* Vol. 134, no. 3473 (21 July 1961), p. 161-164. http://www.sciencemag.org/cgi/reprint/134/3473/161.pdf (2007-03-20)

Williamson, Oliver (2000) The New Institutional Economics: Taking Stock, Looking Ahead. *Journal of Economic Literature*, 38 (3) 595-613.

BIOGRAPHICAL NOTES

Erik Stubkjær is professor of cadastral science (Danish: Matrikelvæsen) at the Department of Development and Planning, Aalborg University, Dennmark, since 1977.

He has written numerous research articles, chapters in books, encyclopaedia entries, and conference contributions with a view to articulate theoretical foundations of the European cadastres. During 2001-2005, he chaired the Management Committee of the research activity *Modelling Real Property Transactions*, which co-ordinated research in 11 European countries and was supported by the EU's ESF-COST scheme as activity G9. During 1996-99, he co-ordinated an EU Phare/ TEMPUS project (S-JEP 11001-96), regarding the restructuring of the study programmes of the Department of Geodesy, Faculty of Civil and Geodetic Engineering, University of Ljubljana, Slovenia.

In May 2003 and again May 2005, he organised the PhD-course 'Cadastral Development – The Contribution of Scientific Enquiry' at the International Doctoral School of Aalborg University, which each attracted a good ten participants from about 8 EU and neighbouring countries. For about ten years, he lectures the course *A theoretical base for cadastral development* within the Master's Programme in Land Management at Real Estate Planning and Land Law, Royal Institute of Technology, Stockholm, and since 1999, he lectures the course *International Land Management*, Maa-20.375, at the Institute of Real Estate Studies, Helsinki University of Technology, Finland

In 2005, Helsinki University of Technology conferred the degree of D. Sc. Technology h.c. to Erik Stubkjær. He is a member of the Danish Association of Chartered Surveyors.

CONTACTS

Professor, Dr. Erik Stubkjaer
Institution: Department of Development and Planning, Aalborg University
Address: Fibigerstraede 11
City: Aalborg
COUNTRY: DENMARK
Tel. + 45 9635 8350
Fax + 45 9815 6541
Email: est@land.aau.dk
Web site: http://www.plan.aau.dk/emp/person.php?pid=113

Geomatics and Geoinformatics in Modern Information Society – Projection of New Trends into their Curricula at the University of West Bohemia in Pilsen

Jiří ŠÍMA, Czech Republic

Key words: geomatics, geoinformatics, developing trends, curriculum for study

SUMMARY

Differences in contents of geomatics and geoinformatics as they are evident in the present situation in the Czech Republic. Partial intersection of them and informatics in generality is illustrated and analysis of recent curricula for geomatics and geoinformatics at the Czech universities and especially at the University of West Bohemia in Pilsen, respecting developing trends of geosciences at the beginning of 21st century, is presented in this paper.

1. GEOMATICS AND GEOINFORMATICS

Spectacular progress in electronics and computer science brought revolutionary changes of scientific and technical disciplines, as e.g. geodesy, cartography, photogrammetry, cadastral and topographic mapping, in the last 25 years. They influenced substantially the style of surveyor´s activities. Traditional tools for his work – survey tape, stakes, theodolite and paper maps have been replaced by new and powerful tools – electronic tacheometry, Global Positioning System, LIDAR, digital photogrammetry, digital cartography and geographic information systems. To-day´s primary products of surveying and mapping are digital databases of geospatial information which can be analyzed, modelled and integrated with other kind of information and presented to the user in digital or graphical form tailored to his specific demands [1]. To-day´s surveyor or cartographer cannot live in close shells of individual disciplines (applied or physical geodesy, topography, photogrammetry, cartography). His profession must become an integrated profession called in many countries **geomatics** or geospatial information engineering [2].

Even if this term is mixed up with the term **geoinformatics** in most Central- and East European countries there is a certain difference in contents what will be evident when comparing curricula for both disciplines at some Czech universities or some official definitions. According to ISO Standard 19122 „geomatics is a discipline concerned with the collection, distribution, storage, analysis, processing, presentation of geographic data or geographic information“. Its range is perfectly described by activities of the Geomatics Canada: „establishing and maintainance of national spatial reference system, preparing, publishing and distributing of state topographical maps, aeronautical charts, aerial photographs and gazetteers, surveys on state boundaries, property surveys on federal lands, maintainance of national bases of geographic data for the development of geographical information systems“. It is in conformity with the definition of geomatics presented at the University in Calgary (Canada): „ Geomatics Engineering is a modern discipline, which integrates acquisition, modelling, analysis and management of spatially referenced data, i.e. data identified according to their locations. Based on the scientific framework of geodesy, it uses terrestrial, marine, airborne, and satellite-based sensors to acquire spatial and other data. It includes the process of transforming spatially referenced data from different sources into common information systems with well-defined accuracy characteristics“ [3].

There is no oficial definition of **geoinformatics** in ISO Standards. One of the best was published by Dietmar Grünreich, president of the Federal Agency for Cartography and Geodesy in Frankfurt (Main): “geoinformatics is a discipline concerned with theory of geospatial data modelling, their storage, management and processing as well as with development of geographic information systems and necessary information and communication technology“[4]. Another pertinent definition can be found in the Wikipedia encyclopedia [5]: „ Geoinformatics is a science which develops and uses information science infrastructure to address the problems of geosciences and related branches of engineering. The three main tasks of geoinformatics are:

- development and management of databases of geodata
- analysis and modelling of geodata
- development and integration of computer tools and software for the first two tasks.“

2. INTERSECTION OF GEOMATICS, GEOINFORMATICS AND INFORMATICS

Certain difference in contents of geomatics and geoinformatics as well as the necessity of partial intersection of them and informatics in generality is evident in **the present situation in the Czech Republic** (see Fig. 1). The main task of disciplines associated in geomatics is the acquisition, storing, processing and delivering of **fundamental** geospatial data and their attributes with required accuracy and relevance. Such data fill up special information systems (e.g. Cadastral Information System) or databases (e.g. of fundamental horizontal and vertical control, Fundamenal Base of Geographic Data ZABAGED and others). Technical means belonging to geoinformatics (e.g. databases, GIS and the means for data interpretation) as well as to general informatics (e.g. hardware, software and telecommunication networks) are necessary for storing, processing and distribution of fundamental geospatial data.

Typical room for geoinformatics is filling up the **thematic** databases which cannot avoid the knowledge of datums and mapping projections as well acquisition of additional geospatial data and attributes using frequently the GPS and remote sensing technologies. Special roles of geoinformatics are **analysis** and **synthesis** of geospatial data with the use of GIS technology which facilitate high-quality **cognition** and sound political, economic and ecological **decision-making** on development of a territory. Another important component of geoinformatics is **visualisation** of geospatial data – not only by means of traditional cartographic methods - but using modern sophistical technologies (e.g. 3D terrain models, modelling of objects on their surface, scene animation, virtual reality). Geographic information science borrow from the information theory regarding to modelling and representation of spatial objects and management of database systems.

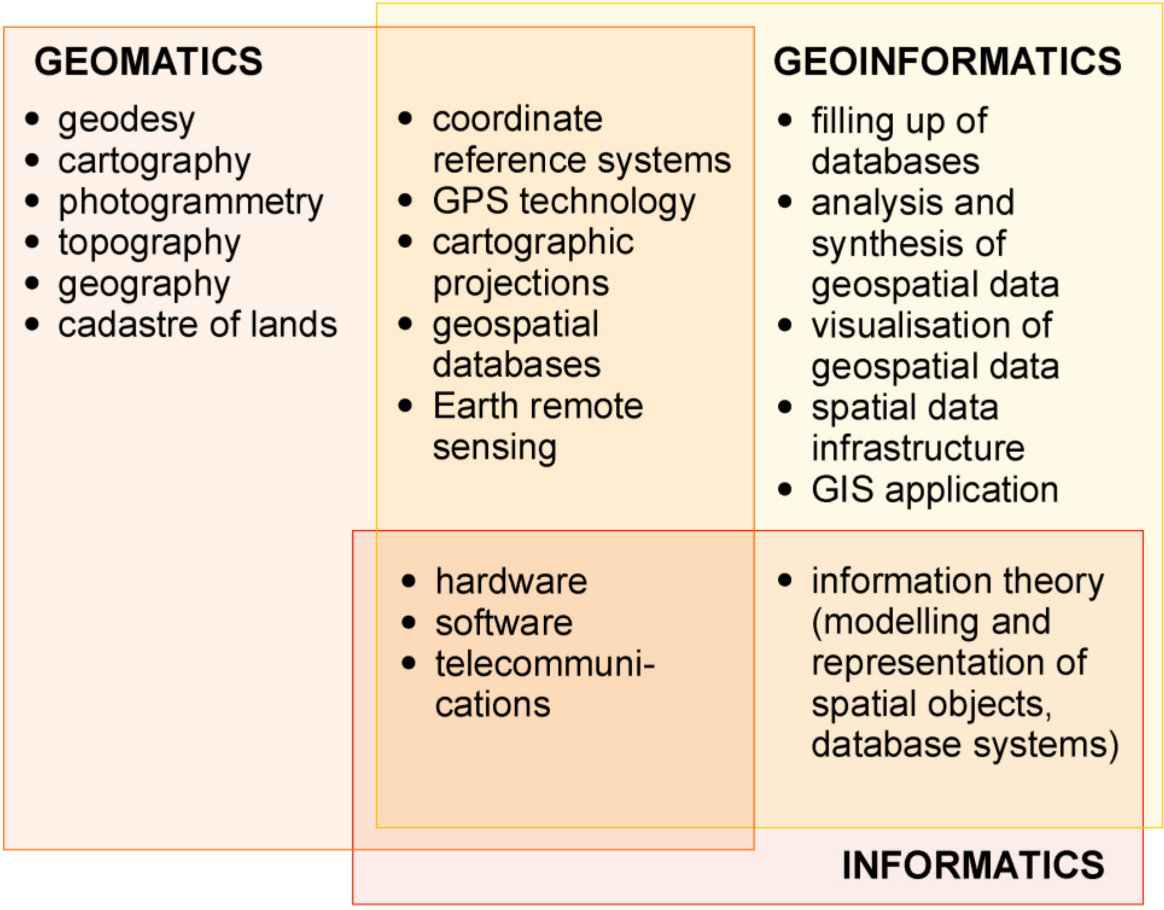


Fig. 1: The present situation in the Czech Republic

3. DEVELOPING TRENDS AT THE BEGINNING OF 21ST CENTURY

In the next 10 years a general harmonization of political and legal environment in the European Union is expected. It enables to create the European geoinformation infrastructure which will be characterized by horizontal interoperability of national geographic databases and by hierarchical interoperability from the level of Land information systems up to national, continental and global geographic databases. Geodata will be generally accessible (e.g. through EU-Geoportal), cross-border geodata exchange will be obvious.

Development of **e-cadastre** of real estates will lead up to the sole information system which will register both ownership rights to real estates inclusive their restrictions, and technical data on owners, lands, buildings and flats. 3-D cadastre will also register and represent underground- and overhead objects of real estate character and locate them in national (later in European) coordinate reference system. Maintenance of national cadastral information systems will be centralized, but on contrary, data distribution to users will be spread into information kiosks of local administration. European Land Information Service (EULIS) will provide the electronic interface which enables the access to national cadastral information systems in Europe. Costs of their services will be fully covered with revenues coming from the fees.

Private surveyors (geomaticians) will be forced to provide the clients with complex services inclusive real estate evaluation and sale. Many stereotype surveying operations will be enough automated so that they will be carried out by people without professional education. As an example the application of robotized total stations for detailed surveys or the system of terrestrial laser scanning for surveying of buildings, streets, industrial objects, engineering constructions and underground objects may be introduced. Surveying and mapping will lead up to the integration of more scientific and technical disciplines (as geomatics or geospatial information engineering).

In **photogrammetry** the transformation of photography into digital image recording will be finalized. The price of large-format digital aerial cameras will be comparable with contemporary film cameras if not cheaper. Spatial position of individual digital images will be derived from directly measured elements of exterior orientation furnished by GPS and inertial measuring unit during the survey flight. Airborne multispectral digital images will be frequently used to various thematic applications. An airborne laser scanner (LIDAR) will beroutinely applied to modelling of terrain or surface relief and their temporal changes.

Development of **physical geodesy** will concentrate on improving the parameters of the Earth body and its gravity field as well as on precising the continental and national coordinate reference systems inclusive their temporal changes. Global positioning system will reach millimeter accuracy in geodetic kinematic applications, too. Dense network of permanent stations in individual countries, currently used by intellectual systems for navigation of persons, cars, ships and airplanes in the real time, will be their component. Temporal-space aspect will be typical for acquisition, processing and analysis of geospatial data.

Remote sensing technologies will utilize many small satellites providing multispectral digital images with large ammount of narrow visible, infrared and thermal wavebands. High resolution satellite digital images will replace to some extent aerial photogrammetry in the case of updating the topographic databases. The methods of automated recognition of spatial and qualitative changes during the time period of updating will be frequently used for this reason. Thanks to capacities and large field-of-view of remote sensing the whole Earth surface inclusive non-inhabited regions will be represented in the form of digital topographic databases at level of 1: 1 million, 1:250 thousand and even 1: 50 thousand mapping by the year 2025.

Cartography will be significantly influenced by the development of information technologies. It seems that it will be above all a service for cartographic visualisation of geospatial data processed by GIS technologies. The map in paper form will not loose its significance entirely but it will be one of tools for education, free time activities and common military purposes only. Other more frequent forms will be electronic maps and atlases, 3D models of landscape, animations, virtual models and intellectual geoimages of multimedia character. Internet will facilitate quick access to cartographic products and it becomes a global geoinformation system. Abandonment of cartographic know-how when creating the GIS software by IT- people only (e.g. principles of cartographic generalization, application of sofisticate map language) could lead up to distribution and using the impressive and quick working software but not always giving meaningful outputs.

Analysis of future trends and applications of geosciences which are tied in with geomatics and geoinformatics illustrates how deep will be changed the profession of today´s surveyor and cartographer in coming information age. Focus of their activities will transfer from labour-intensive acquisition of geospatial data to their processing, maintainance and presentation for the needs of scienfitic, administrative, legal and technical operations. The curricula for geomatics and geoinformatics should reflect above mentioned trends [6].

4. PROJECTION OF NEW TRENDS INTO CURRICULA FOR GEOMATICS AND GEINFORMATICS AT THE UNIVERSITY OF WEST BOHEMIA IN PILSEN

Modern conception of geomatics was accepted by the University of West Bohemia in Pilsen as early as 1995 and projected into curricula for B.Sc., M.Sc., and Ph.D. studies of geomatics. Other universities in the Czech Republic follow more or less the objectives of geoinformatics described by Dietmar Grünreich. Because of a great demand for skilled technicians in geoinformatics the B.Sc. - curricula for geoinformatics is being accreditated at the University of West Bohemia in Pilsen in 2007. Composition of aboved mentioned curricula (see Table 1 and 2) is based on profound analysis of future trends and applications of geosciences which are tied in with geomatics and geoinformatics. Future legal and political environment in Europe that can influence substantionally the level of global, European and national infrastructure of geospatial data has been also taken into consideration.

Table 1 a): B.Sc. - curriculum for geomatics (3 years). The overview does not contain subjects of general fundamentals (mathematics, physics, statistics, etc.).

Subject	Year/Term	Lecture + Seminar
Mathematical cartography I	2/ WT	2 + 2
Geodesy I, II	2/ WT + 2/ ST	3 + 2
Topographic mapping	2/ ST	2 + 2
Introduction to GIS	2/ ST	2 + 1
Civil material law	2/ ST	2 + 0
Land law	2/ ST	2 + 2
Geodetical methods of adjustment	3/ WT	2 + 1
Cadastre of real estates	3/ WT	2 + 2
Programming techniques	3/ WT	3 + 2
Thematic cartography	3/ WT	2 + 1
Large scale mapping	3/ WT	2 + 0
Automation of geodetical computations	3/ WT + 3/ ST	2 + 2
Photogrammetry	3/ ST	2 + 2
Differential geometry	3/ ST	2 + 2

Bachelor study programme Geomatics has two main objectives:

1) to prepare the graduate for continuing in master study at the Faculty of Applied Sciences or for similar study programme at other Czech university or abroad,
2) to prepare the graduate for practically oriented professional activities particularly in the field of
    - acquisition and processing of geospatial data
    - filling up the geospatial data funds and their updating

- maintenance of cadastre of real estates
- surveying for land consolidation projects
- land evaluation and real estate market

Bachelor study programme Geomatics requires three-year study concluded by the state examination and viva voce of a bachelor project in the study field „Geodesy, Cadastre of Real Estates and Civil Material Law".

Table 1 b): M.Sc. - curriculum for geomatics (+ 2 years).

Subject	Year/Term	Lecture + Seminar
Physical geodesy	1/ WT	2 + 2
Earth remote sensing	1/ WT	2 + 2
GIS in human geography	1/ WT	1 + 2
Algorithms of space analyses	1/ WT	1 + 2
Theory of GIS generation	1/ WT	3 + 2
Database systems I	1/ WT	3 + 2
Cartographic reproduction and polygraphy	1/ WT	2 + 2
Global positioning systems	1/ ST	2 + 0
Database systems II	1/ ST	3 + 2
Geometric and computer modelling	1/ ST	3 + 2
GIS in physical geography	1/ ST	1 + 2
GIS applications	1/ ST	1 + 2
Database systems for GIS	1/ ST	2 + 2
Mathematical cartography II	1/ ST	2 + 2
Administrative law	2/ WT	2 + 0
Algorithms of computer graphics	2/ WT	3 + 2
Computer cartography	2/ WT	1 + 2
Data visualisation	2/ ST	3 + 2
Digital image processing	2/ ST	3 + 2
Satellite geodesy	2/ ST	3 + 2
Theory of law	1/WT + 1/ST + 2/WT + 2/ST	2 + 2

Table 2: Comparison of B.Sc. - curriculum for geomatics with proposed B.Sc. - curriculum for geoinformatics. The overview does not contain subjects of general fundamentals (mathematics, physics, statistics, etc.).

Geomatics	Geoinformatics
Mathematical cartography I	Introduction to geomatics
Geodesy I, II	Geodesy I, II
Topographic mapping	Terminology and standardization in geoinformatics
Introduction to GIS	Introduction to GIS
Civil material law	Modern methods of geodata acquisition
Land law	Cartographic visualisation of geoinformation
Geodetical methods of adjustment	Information technologies for geographic data
Cadastre of real estates	Methods of topographic and large scale thematic mapping
Programming techniques	Programming techniques
Thematic cartography	Thematic cartography
Automation of geodetical computations	Computer cartography
Large scale mapping	Spatial databases
Photogrammetry	Programming of internet applications
Differential geometry	Computer networks

The purpose of **master study programme Geomatics** is to prepare engineers capable to manage challenging work in geodesy, photogrammetry, remote sensing, cartography and cadastre of real estates using modern means of information technologies. The study programme is primarily guaranteed by the Faculty of Applied Sciences (departments of mathematics, informatics and computer science) but legal subjects are being taught at the Faculty of Law. Home environment for the section of Geomatics, which is the guarantor of the above mentioned study programme, has been found within the Department of Mathematics. This department ensures teaching of all advanced mathematical disciplines as e.g. differential geometry, geometrical and computer modelling, ordinary and partial differential equations inclusive of guiding the disserations focused on mathematical and geometrical problems.

Master study programme Geomatics requires five-year study concluded by the state examination and viva voce of a dissertation in the study fields „Geodesy and Geographic Information Systems“, „Cartography“ or „Cadastre of Real Estates and Civil Law“.

The average annual number of graduates in Geomatics at the University of West Bohemia in Pilsen is up to 20 masters and 30 bachelors. Thanks to their good knowledge of geoinformation technologies almost all of them find the adequate job in the state sector of surveying, mapping and cadastre, in bodies of public administration or in private land surveying firms.

The newly introduced **bachelor study programme Geoinformatics** has two main objectives:

1) management and distribution of geospatial data and services in the environment of distributed processing,
2) application of geoinformation technologies.

That is why the bachelor study programme will be focused on

- practical knowledge of basic standards of geographic information (ISO, OGC, OASIS, W3C, ČSN EN, ČSN)
- metadata systems
- overview of existing geospatial databases and their usability
- general knowledge of geodata acquisition
- detailed knowledge of geodata processing
- managing and delivery of volumenous geodata sets
- web services and web servers (geoportals) for geodata distribution.

Graduates of the bachelor study programme Geoinformatics will find the job in the public administration bodies (e.g. regional, town and municipality offices), in private firms developing GIS and web applications of geoinformation, eventually in the crisis management as well.

REFERENCES

[1] ZARZYCKI, G. J. M.: From pens to digits and pixels. A overview of evolution in photogrammetric mapping. In Prace Instytutu geodezji i kartografii. Warszawa: IGiK 2001. t. XLVIII, z. 104, s. 21 – 30.
[2] TRINDER, J. – HAN, S.: Impact of new technologies on geomatics. Australian Surveyor 1999, No 1, p. 29 – 34.
[3] http://www.geomatics.ucalgary.ca/whatisit/index.html
[4] HAKE, G. – GRÜNREICH, D. - LIQIU MENG: Kartographie. 8. Auflage. Berlin – New York: de Gruyter 2002. 604 p. ISBN 3-11-016404-3.
[5] http://en.wikipedia.org/wiki/Geoinformatics
[6] ŠÍMA, J.: Geomatika a geoinformatika v moderní informační společnosti. In Sborník přednášek 42. geodetické informační dny. Brno: Spolek zeměměřičů, 2006.

BIOGRAPHICAL NOTES

Jiří ŠÍMA is a senior lecturer (Assoc. Prof.) at the University of West Bohemia in Pilsen.
In 1993-2001 he served as a president of the Czech Office for Surveying, Mapping and Cadastre. His fields of interest are photogrammetry, topographic mapping and standardization of the Czech terminology in geoinformatics.

CONTACTS

Doc. Ing. Jiří Šíma, CSc.
Západočeská univerzita v Plzni
Univerzitní 22
306 14 Plzeň
CZECH REPUBLIC
Tel. + 420 608 279 789
Fax + 420 377 632 602
Email: simaj@kma.zcu.cz
Web site: www.kma.zcu.cz

A Blended Learning Course for Thematic Cartography

Zuzana ŠŤÁVOVÁ, Vilém PECHANEC, Vít VOŽENÍLEK, Czech Republic

Key words: blended learning, thematic cartography, LMS Moodle, feedback, knowledge sharing, cartographic literacy

SUMMARY

The increase of cartographic literacy today is enabled within the traditional educational process occurring at school, as well as by various forms of education, such as e-learning or blended learning. Thematic cartography taught in the form of the so-called blended learning is one of the courses provided by the Department of Geoinformatics at the Faculty of Science, Palacký University in Olomouc in the framework of a pilot project of integration of e-learning. Blended learning combines technology-based materials, face to face sessions and printed materials. This article describes the aspects influencing the organisation of this kind of learning, the preparation of study materials or learning activities, as well as problems and obstacles encountered during the preparation of the course and during the actual integration of LMS and e-learning. We have choosen the LMS Moodle for the online portion of the course and we placed an emphasis on educational activities, knowledge sharing and teamwork in a didactic scenario for the entire course. The total conception of teaching the above-mentioned course is outlined and particular examples are introduced.

1. INTRODUCTION

The development of information technologies is one of the most influential factors in the development of national economies. As its consequence, an information society has risen, which has pushed forward distinctly the American economy before the Japanese and European economies. An efficient processing of spatial information is a part of a developed information society. This does not only concern the ability to produce maps, but mainly the habit to create systematically, to process efficiently, to manage efficiently, to analyse in a sophisticated way, and to visualise efficiently various spatial information. A map is essential in this process; however, the key issue being the perception of space through information encoded in digital data, the most important prerequisite is the acquisition of an appropriate degree of cartographic literacy. While the development in using computer hardware, software and telecommunications is very fast, the perception of space, fast and correct spatial decision making and expressing the spatial information (instructions, commands, intentions) is the weak point of many societies (not only the Czech one). The increase of cartographic literacy today is enabled within the traditional educational process occurring at school, as well as by various forms of education, such as e-learning or blended learning etc.

2. CARTOGRAPHIC LITERACY

The cartographic literacy represents the ability to read maps and the skill to create maps. Reading maps consists in the perception of a map (its graphics), using the legend and understanding the content of a map. This is a process of acquiring information due to the knowledge of a map language. There are two kinds of cartographic literacy: natural (innate) and acquired additionally (by learning) (Pravda 2001). The innate cartographic literacy is a skill natural for some as it is part of their consciousness, mind processes, and cognition.

Cartographic literacy is a complex term that has three degrees: comprehension, use and development. Comprehension represents understanding the content, demands of the activities, and knowledge of the creation and the use of maps and their outputs, both paper and digital. All experts who use maps within their professions, team with cartographers, or manage cartographers, should acquire the degree of cartographic literacy comprehension. The degree of use is represented in the form of a professional cartographer, who creates maps for various purposes and in various forms. Their outputs can bear demanding professional criteria and are traditionally the most commonly required outputs of research work. The degree of development in cartographic literacy belongs to academic teachers, managers of cartographic organisations, development workers and other experts who determine the trends of development of geovisualisation technologies and publish the essential theoretical aspects of cartographic fields.

The cartographic literacy requirements vary. However, they are on the increase today and their importance is growing. Cartography-literate experts are required as members of research teams, as well as workers on important decision-making posts. It is most desirable that part of the professional training in many professions be a particular cartographic education. Cartographic literacy acquired on all the three degrees introduces wide opportunities of spatial activities in the function of a knowledge-based society, as it enables:

- Better availability of spatial information via digital maps on the internet or wireless telecommunication networks,
- More precise and efficient spatial decision-making (including the economic and political ones) since most of them happen over maps,
- Development of better technologies to support the management, analysis and visualisation of spatial data and their interconnection with other (non-spatial) systems,
- Concentration of new knowledge and experience in geo-applications and the implementation of space-based approaches to many areas (and thus to a wider spectrum of practical activities).

There is a great danger in the technological potential, i.e. the lack of understanding and applying the principals of cartography. This can be seen in most czech and foreign GIS conferences when carefully studying the displayed map products. A great number of them are inconvenient – the scale is missing, the composition is incorrect, the legend is disorganised or dependent, etc. The value of thus presented information is much lower and the result of cartographic attempts is inapplicable. That is another reason why it is necessary to observe the cartographic literacy development, especially in the field of digital cartography (Voženílek 2002).

3. PILOT PROJECT

A year-long pilot project of integrating e-learning into modules and professional preparation of cartographers was launched in the summer semester 2007 at the Department of Geoinformatics at the Faculty of Science, Palacký University in Olomouc. It also includes the course Thematic cartography (TEMAK), which is provided in the form of blended learning to the students in a study of Geography & Geoinformatics; the students are provided this course with regard to their rather high computer literacy which enables them to elaborate and submit the tasked assignments (maps) in the digital form.

Blended learning combines face-to-face sessions and e-learning, i.e. it combines live presentations or workshops, seminars or courses with electronic education accomplished using the information and communication technologies (ICT). LMS Moodle has been introduced to support and manage classes with regard to its OpenSource character and a wide range of tools that it offers to the course administrator, as well as the tutors and students.
Four courses are running at present in the form of e-learning or blended learning, two of which are managed by internal workers of the Department of Geoinformatics, one is managed by and external tutor and one course is managed by a worker of the Department of Geography at the Faculty of Science, Palacký University in Olomouc.

4. COURSE MANAGEMENT

It was necessary to select a suitable LMS (Learning Management System) and to determine the complete conception of the e-learning at the beginning.

We have chosen the LMS Moodle; the reasons are given below. Then a didactic scenario of individual courses and e-learning has been created at our department.

4.1 LMS Moodle

To realise e-learning and blended learning courses, we have decided to use a module object-oriented educational environment. The reasons follow:

- licence policy – Moodle is an OpenSource project and the program interface is dispensed under the GNU/GPL licence, therefore it is free. That helped significantly to make the decision whether to attempt e-learning at all. The smooth availability of the system, which enables a free trial of all tools without limitations followed by the shift into real use, without financial demands and other commitments, has helped us create e-learning and blended learning courses.
- Demands on the student – the pleasant and well-arranged user interface (WYSIWYG editor, among others) is not demanding on computer literacy of students, basic computer skills suffice to operate this environment. The student is in an internet browser

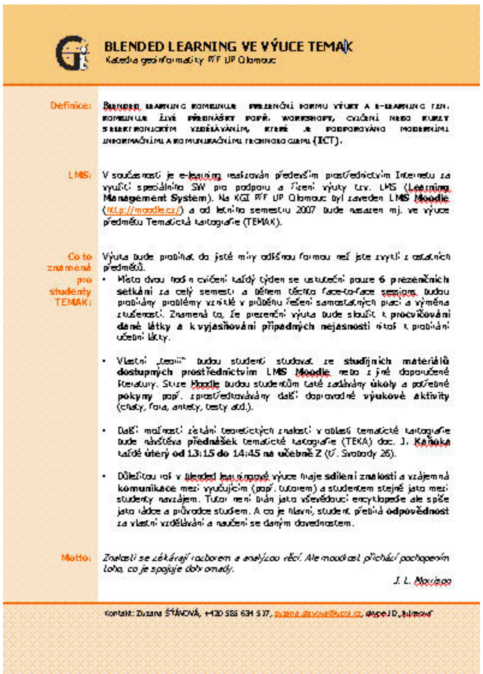
environment and clicks the individual hypertext links. Perfect information on the user's steps supports orienting in the individual courses.

- Availability of the system – it is one of the most widely spread LMS in the Czech Republic, as well as abroad, which leads to the existence of a great amount of documentation, discussion forums, and wiki systems oriented on system management and use, therefore searching the solutions of possible problems is fast.
- Extent of localisation into the national environment – the system is fully localised and supports individual selection of various language mutations for the complete interface. The presence of the Czech environment is favourable for many students during their first encounter with this type of study.
- Authorised access anywhere – the system enables defining the individual roles of the course creator and the tutor, while it provides the registered logged-on person the opportunity to create/edit the course from any spot.
- Technical requirements on the system – as we had known since the very beginning that we wanted to run the LMS on our own server, we looked for a solution compatible with the basic technologies that had already been installed on the server. Considering the use of a proved combination of Apache + PHP + mySQL, Moodle was our primary choice. The current Moodle installation is the 1.7+ for Windows version and it runs on our departmental server. It is a one-processor server with two physical hard-disks and the Windows Server 2003 operation system. The server is located in the university server room, which is centrally protected against power failure and over-voltage shock, has steady temperature, finite dustiness, and authorised access. The web server Apache 2.2.3 complemented with the PHP script language, version 5.1.6 and the database instrument mySQL 5.0.24 complemented with the phpMayAdmin 2.9.3 database manager. A continuous task check of selected courses of the Moodle system is handled by the complementary PHP script Moodle cron for Windows. Both the database contents and the application file system are regularly backed up in a weekly cycle of a complete back-up using the Cobian back up 8 system.

4.2 Learning Conception

All students who signed for any course offered in the form of e-learning or blended learning were e-mailed basic information of this form of learning (see Fig. 1).

There were entrance tutorials at the beginning of the semester which were outlined as instructions for organisation of the course, work with the LMS Moodle including filling in their profiles and terms of successful passing of the individual courses. The students were given enrolment keys needed to sign for the individual courses.



BLENDED LEARNING VE VÝUCE TEMAK
Katedra geoinformatiky PřF UP Olomouc

Definice: Blended learning kombinuje prezenční formu výuky a e-learning tzn. kombinuje živé přednášky popř. workshopy, cvičení nebo kurzy s elektronickým vzděláváním, které je podporováno moderními informačními a komunikačními technologiemi (ICT).

LMS: V současnosti je e-learning realizován především prostřednictvím Internetu za využití speciálního SW pro podporu a řízení výuky tzv. LMS (**Learning Management System**). Na KGI PřF UP Olomouc byl zaveden LMS **Moodle** (http://moodle.cz/) a od letního semestru 2007 bude nasazen mj. ve výuce předmětu Tematická kartografie (TEMAK).

Co to znamená pro studenty TEMAK: Výuka bude probíhat do jisté míry odlišnou formou než jste zvyklí z ostatních předmětů.

- Místo dvou hodin cvičení každý týden se uskuteční pouze **6 prezenčních setkání** za celý semestr a během těchto face-to-face sessions budou probírány problémy vzniklé v průběhu řešení samostatných prací a výměna zkušeností. Znamená to, že prezenční výuka bude sloužit k **procvičování dané látky a k vyjasňování případných nejasností** nikoli k probírání učební látky.
- Vlastní „teorii" budou studenti studovat ze **studijních materiálů dostupných prostřednictvím LMS Moodle** nebo z jiné doporučené literatury. Skrze Moodle budou studentům také zadávány **úkoly** a potřebné **pokyny** popř. zprostředkovávány další doprovodné **výukové aktivity** (chaty, fora, ankety, testy atd.).
- Další možností získání teoretických znalostí v oblasti tematické kartografie bude návštěva **přednášek** tematické kartografie (TEKA) doc. J. Kaňoka každé **úterý od 13:15 do 14:45 na učebně Z** (tř. Svobody 26).
- Důležitou roli v blended learningové výuce hraje **sdílení znalostí a vzájemná komunikace** mezi vyučujícím (popř. tutorem) a studentem stejně jako mezi studenty navzájem. Tutor není brán jako vševědoucí encyklopedie ale spíše jako rádce a průvodce studiem. A co je hlavní, student přebírá **odpovědnost** za vlastní vzdělávání a naučení se daným dovednostem.

Motto: *Znalosti se získávají rozborem a analýzou věcí. Ale moudrost přichází pochopením toho, co je spojuje dohromady.*
J. L. Morison

Kontakt: Zuzana ŠŤÁVOVÁ, +420 585 634 517, zuzana.stavova@upol.cz, skype ID „tulmova"

Fig. 1: Information leaflet for students who signed for the TEMAK course, which is taught in the form of blended learning at the Department of Geoinformatics at the Faculty of Science, Palacký University in Olomouc in the summer semester 2007

If a course is taught in the form of blended learning, face to face meetings are organised during the semester where issues connected with the students´ individual works are discussed and the students exchange their experience. Thus these meetings do not serve to cover the learning matters but their practising. The theory itself is then covered by the students who use the study materials available in LMS Moodle or other recommended literature sources.

The students are set their tasks and instructions or other accompanying learning activities (forums, dictionaries, surveys, etc) via Moodle. The philosophy of work and learning in the LMS Moodle environment lies in the active participation of students, i.e. contributions in discussion forums, voting in surveys, filling-in online tests or elaborating written assignments and their submission in the electronic form.

5. THEMATIC CATOGRAPHY COURSE

The Thematic cartography course (TEMAK) is divided into 12 modules, where the number of modules follows from the number of weeks in the summer semester, and 6 face to face meetings are organised. The output of most tasks assigned to the students in the framework of TEMAK is a digital map, which must comply with the given criteria of cartographic "correctness". Acquiring practical skills is emphasised in the course, i.e. the students should be able to apply all the theoretical knowledge in practice in the form of creating their own maps. Knowledge sharing and mutual communication between the tutor and the student and among the students play an important role in the modules.

5.1 Didactic Scenario of the Course

Each TEMAK module contains these basic elements: instructions for self-study, a file containing study materials and their brief description, and a forum related to the taught issues. Following the motto *”Knowledge is gained by analysing the issue. Wisdom, however, comes with understanding what connects them“*, the students are gradually tasked assignments and exercises. Each assignment comes with instructions for assignment and instructions for foundation input data preparation for accomplishing this assignment. The individual assignments usually comprise the acquisition of materials from more modules, therefore there is not one assignment in each module, but after concluding a particular theme. A requirement for passing the course is the submission of the elaborated assignments (in the digital form). There are also exercises to practise and acquire the given learning issue apart from the assignments. Their elaboration is optional and depends on each student’s activity. There are also links related to particular examples of the covered theme, e.g. maps or suggestions for further self-study. To motivate students to fulfil these optional activities, the best performances are awarded with cartographic and geoinformatic prizes, e.g. books, magazines, CDs, or materials from companies dealing with cartography or geoinformatics.

Apart from the partial assignments, the students were tasked a semestral work at the beginning of the semester, which serves as a test of the skills gained during the whole semester. The main part of the semestral work is a semestral map of the A2 format at least (see Fig. 2) which represents an application of the acquired knowledge on a particular theme of their map. The themes of the semestral work are not limited by their relevance, space, or time, the aim being the student choosing a theme s/he is interested in. The students may be motivated by their possible participation in the prestigious Map of the Year competition, which is organised by the Czech Cartographic Society, and where the most successful maps will be sent at the end of the semester. The students will present their work at the so-called final tutorial, where the course will be concluded in the form of an oral defence of their semestral work with the participation of all other participants and tutors, with a public discussion over the course and the content of the whole course, including comments on individual issues.

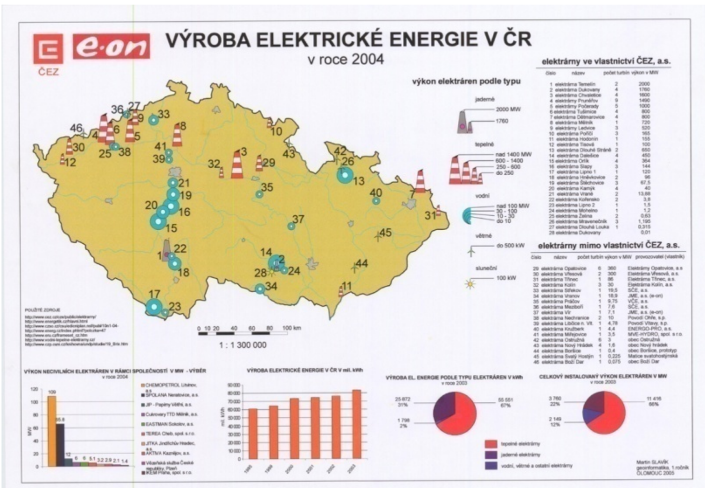


Fig. 2: An example of a semestral map elaborated by a student in the framework of TEMAK

The face-to-face meetings, as well as in the course of the e-learning part, the comprehension and acquisition of the given learning issue are emphasised. The students are asked to contemplate independently the given issue and its solution or to cooperate in pairs or in groups. It is important to involve creativity, brainstorming and the ability to sort and process information on the given theme and to find an optimal solution.

To be more particular about TEMAK, the following part of this article describes some modules and related learning activities.

5.2 Examples of Learning Activities

The course of Thematic cartography follows from what students learned in the winter semester in the framework of a basic course concerning geographic cartography and geographic information systems.

As mentioned above, the outcome of most assignments tasked to the students in the framework of TEMAK is a map that the students submit in the digital form through Moodle (.jpg, .tif, .pdf formats). It is not necessary to know particular software to create maps, it depends on which program the students choose to process their tasked assignments.

The students study the given study issue before the actual elaboration of the assignment, e.g. the methods of choropleth maps (the individual cartographic expressing methods used for illustration of both quantitative and qualitative data in the map are covered gradually during the semester). Each method is related with appropriate expressing means, i.e. it is necessary to introduce e.g. the use of different colours for quantitative distinguishing of phenomena together with the choropleth maps. While the chapter on the colours used for quantitative distinguishing of phenomena follows the chapter of choropleth maps, the chapter on the choropleth maps was preceded by the chapter devoted to the data classifications and the creation of classes for choropleth maps and proportional symbol maps, etc. This means that the individual chapters are closely related and follow each other and refer to each other, however, the learning issue is covered as a whole.

When a student covers the study materials set for the self-study, s/he is asked to elaborate the assignment which will prove the student's grasp of the given study issue. The student must prepare the needed data to elaborate a map. The instructions are given in the presentation concerning data preparation (where to gain data, what kind of data, how to pre-process them, etc., see Fig. 3)

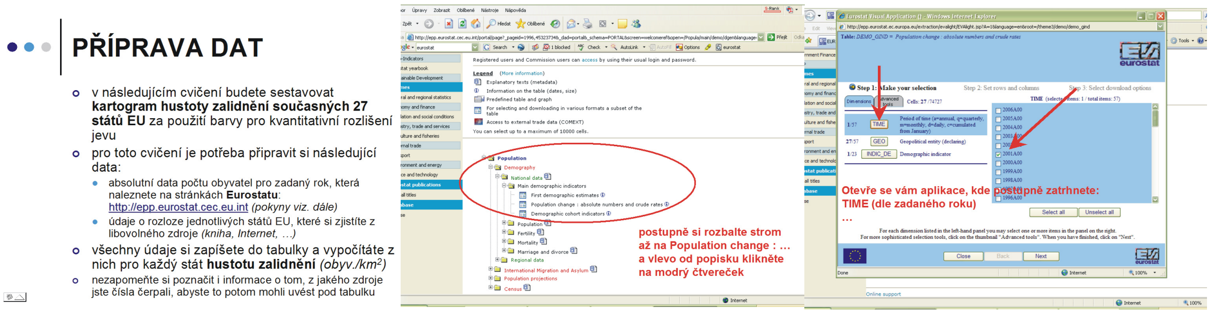


Fig. 3: Presentation concerning data preparation needed to elaborate the assigned assignment

The students find detailed instructions in the assignment concerning the appearance of the map, the deadline and the form of submission, and they can discuss possible problems through a forum that comes with the given assignment. For example, one of the assignments is to create a choropleth map of population density of the European Union countries in the given year using the colour and raster for quantitative distinguishing of phenomena and to add both the composition elements, such as the title, scale, the table of input data and the quotation of the information source etc.

Some examples of other assignments are creations of the proportional symbol map for Moravian and Silesian districts based on the data from the czech census of population 2001, the chorochromatic map of the land use according to the data of the Ministry of the Environment of the Czech Republic or the dot map to represent the data from the Institute of information in education of the Czech Republic databases.

Apart from maps, text protocols are the output of some assignment, e.g. a critical evaluation of a chosen map, a report on czech thematic maps, or the assignment of an "ACS maps", where the students in pairs choose an appropriate example of analytical, complex, and synthetic maps in ESRI Map Book.

If the assignment is submitted in the digital form and the required format, the tutor studies it and write notes "directly in the map" (see Fig. 4) or in a text and sends the assignment back to the student to remake it. This process repeats until the map is perfect and the given assignment is accepted as fulfilled.

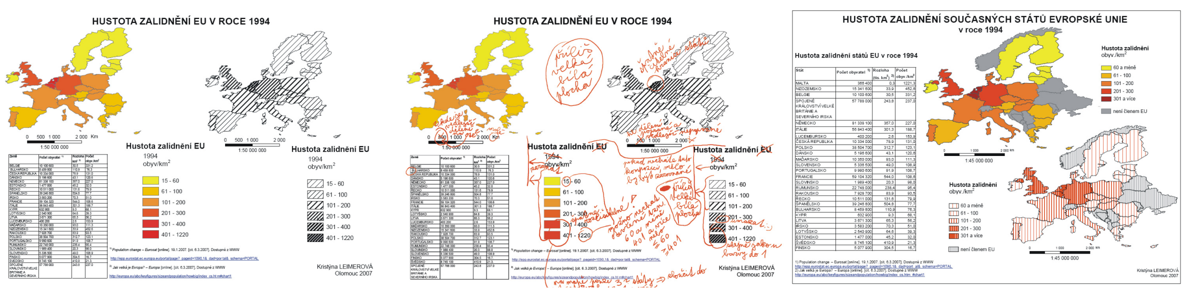


Fig. 4: A assignment elaborated by a student, notes written by the tutor, and the remade map

Apart from the assignments and forums, the student may study the related literature or links, e.g. view the choropleth maps in the atlas of the American census, read how to quote correctly from a source of information according to the standard ISO 690 or try some of the courses provided by the company ESRI in the framework of the so-called Virtual Campus. Furthermore, some chapters include learning activities, such as the creation of a dictionary where both the students and the tutor can add, rearrange and comment on the individual entries concerning the given topic, e.g. diagrams in maps. An example of a two-week TEMAK module plan, see below.

26th February 4th March

Choropleth Maps and Colours

Self-study

ColorBrewer

Choropleth maps in "Mapping Census 2000 : The Geography of U.S. Diversity" atlas

3_study materials

Competition of "The best colour choropleth maps"

- you can input your choropleth maps **here** and win one of the prices

Possibilities of quantitative data classification in ArcGIS 9

5th March 11th March

Raster and the First Map

Self-study

How to quote correctly

4_study materials

Data preparation

The first map

- attention, your first big assignment

Forum – Help each other

Have you tried ESRI Virtual Campus?

5.3 Communication and Feedback

Knowledge sharing and mutual communication between the tutor and the student or among the students play an important part in blended learning. The tutor is not perceived as an omniscient encyclopaedia, but rather as an adviser and guide through the study. The student thus assumes the responsibility for his/her own study and acquisition of the necessary skills, similar to the "full" e-learning.

Apart from the individual modules, in TEMAK there are several forums concerning the modules and forums dealing with cartography and maps in general, where the students share e.g. their experience with map creation, ideas for semestral work, tips for exhibitions or links to the best map servers. There is also a forum dealing with technical problems (the so-called technical plane) and a forum enabling a more personal contact of students on a less "official" level (the so-called social level). Each student can launch a discussion in any forum on a selected topic or add a contribution to an existing discussion.

The students can send messages through Moodle and e-mail to communicate with their tutor – those are examples of asynchronous communication tools. Some examples of synchronous tools are contacting the tutor through Skype or a telephone line.

The so-called SWOT analysis will be a crucial tool to evaluate the whole pilot project; it will identify the strengths and weaknesses, as well as opportunities and threats. It will follow from evaluating the feedback based on observable in the students´ activities during the semester, their reactions in the forums, their participation in optional competitions, or the activities during the face-to-face meetings. We also want to use surveys and questionnaires and to evaluate the overall as well as the partial results following the view of the tutor and the LMS administrator.

6. CONCLUSION

We have only started using blended learning and e-learning at the Department of Geoinformatics at the Faculty of Science, Palacký University in Olomouc, and we still have to deal with a number of troubles and problems both of a technical and pedagogic character. Nevertheless, we definitely intend to continue this form of learning as the present reactions of students are very favourable and show that they find this way of learning appealing and that they have gained a totally new view of learning and study.
Regarding the fact that anybody at the Faculty of Science, Palacký University in Olomouc has never used the possibilities offered by e-learning, we welcome any critical comments or advice.

7. ACKNOWLEDGEMENT

This paper is a part of the project GA ČR 205/06/0965 – Visualisation, interpretation and perception of spatial information on thematic maps.

REFERENCES

FRANC, D. *Rovnice pro e-learning*. Centrum distančního vzdělávání Univerzity Palackého v Olomouci, Olomouc, 2006

MATLESS, D. *The Uses of Cartographic Literacy*. In: Cosgrove, D. (ed): Mapping. Reaktion Books, 1999

moodle [online]. [cit. 23. 3. 2007]. Dostupné z WWW: <http://moodle.org>

moodle [online]. [cit. 23. 3. 2007]. Dostupné z WWW: <http://moodle.cz>

NOCAR, D. *Distanční vzdělávání a e-learning*. Vydavatelství Univerzity Palackého v Olomouci, Olomouc, 2006

PRAVDA, J. *Kartografická gramotnost, čítanie máp a generovanie poznatkov z máp*. Geodetický a kartografický obzor, roč. 47/89, č. 8-9, 2001

VOŽENÍLEK, V. *Geoinformatická gramotnost: nezbytnost nebo nesmysl?* Geografie – Sborník ČGS, roč. 107, č. 4, 2002

VOŽENÍLEK, V. *Cartography for GIS – geovisualization and map communication*. Univerzity Palackého v Olomouci, Olomouc, 2005

BIOGRAPHICAL NOTES

Zuzana Šťávová is a lecturer of the Department of Geoinformatics at Palacký University in Olomouc, Czech Republic. Her papers are dealing with thematic cartography, cartographic education and urban planning.
Vilém Pechanec is a lecturer of the Department of Geoinformatics at Palacký University in Olomouc, Czech Republic. His papers are dealing with using of IT and GIT (chiefly GPS) and environmental studies.
Vít Voženílek is an associate professor of the Department of Geoinformatics at Palacký University in Olomouc, Czech Republic. His papers are dealing with computer cartography, atlas cartography, cartographic education, thematic mapping, spatial phenomena modelling and geoinformatics. He is managing several atlas projects like Climate Atlas of the Czech Republic, Landscape Atlas of the Czech Republic, Atlas of the Natural Extremes of the Czech Republic etc.

CONTACTS

Mgr. Zuzana Šťávová; Mgr. Vilém Pechanec, PhD.; doc. RNDr. Vít Voženílek, CSc.
Department of Geoinformatics, Faculty of Science, Palacký University in Olomouc
tř. Svobody 26
Olomouc, 77146
CZECH REPUBLIC
Tel. +420 585 634 517
Email: zuzana.stavova@upol.cz, vilem.pechanec@upol.cz, vit.vozenilek@upol.cz
Web site: http://www.geoinformatics.upol.cz, http://gislib.upol.cz

Surveying Education and Marketing of Surveying Education in Finland

Arvo VITIKAINEN, Finland

Key words: surveying education, marketing of surveying education

SUMMARY

Surveying education is offered on three different levels in Finland. The first degree in surveying after basic studies is the cartographer. Bachelors of Science (Tech.) in Surveying are graduated from Polytechnics and Masters of Science (Tech.) in Real Estate Economics, and Masters of Science (Tech.) in Geomatics are graduated from Helsinki University of Technology. The degree structure at Helsinki University of Technology is two-stage consisting of a lower and a higher academic degree. Three years of studies will lead to the degree of Bachelor of Science in Technology and the following two years of studies will lead to the degree of Master of Science in Technology.

General trend in the surveying field in Finland in the 1990's was that enrolment to surveying education dropped year by year on all of the three education levels. Surveying education interested too few young people in the late 1990's and many educational institutions had less applicants than open posts. At the same time it was obvious that by the year 2010 about a half of the surveyors working in the late 1990's would retire offering plenty of vacant situations. In this situation the occupational organisations, educational institutions and biggest employers in the field awoke to consider how this change of generation would be implemented successfully and how the marketing and introduction of the surveying field in comprehensive and secondary schools would be enhanced to make more and more young people choose surveying as future profession.

This threat of decline in the surveying field made the occupational organisations, educational institutions and employers form a joint marketing team (Imago Team) for planning and realising actions for marketing surveying education among the young generation. Simultaneously and in co-operation with the Imago Team the educational institutions are also enhancing their own marketing. As a result of this work the familiarity of surveying has increased among the young generation and enrolment to various educational institutions has started to increase.

This paper considers the surveying education, the degree structure at the Helsinki University of Technology and the various marketing methods and channels used in Finland in the 21st century for increasing the familiarity of surveying education and interest in the field among the young generation.

1. INTRODUCTION

The Finnish education system is composed of nine-year basic education (comprehensive school), preceded by one year of voluntary pre-primary education; upper secondary education, comprising vocational and general education; and higher education, provided by polytechnics and universities (see Figure 1).

Basic education is free general education provided for the whole age group (currently c. 60,000 children). After completing the basic education syllabus young people have finished their compulsory schooling. It does not lead to any qualification but gives eligibility for all upper secondary education and training.

The post-compulsory upper secondary level comprises general and vocational education. Both of the forms usually take three years and give eligibility for higher education. About 55% of the school-leavers opt for the general upper secondary school (high school) and 39% initial vocational education and training school (VET).

The upper secondary school (high school) is based on courses with no specified year-classes and ends in a matriculation examination. It does not qualify for any occupation. After the upper secondary school, students continue in universities, polytechnics or vocational institutions. The aim of vocational education and training school (VET) is to improve the skills of the work force, to respond to skills needs in the working life and to support lifelong learning.

The Finnish higher education system consists of two complementary sectors: polytechnics (universities of applied sciences) and universities. The mission of universities is to conduct scientific research and provide instruction and postgraduate education based on it. Polytechnics train professionals in response to labour market needs and conduct research and development (R&D), which supports instruction and promotes regional development in particular.

The studies in universities and polytechnics are quantified as credits (European Credit Transfer System - ECTS). One year of full-time study corresponds to 60 credits. The extent of polytechnic degree studies is generally 210 to 240 credits, which means 3.5 to 4 years of full-time study. This education is arranged as degree programmes. The entry requirement is a certificate from an upper secondary school or the matriculation certificate, a vocational qualification or corresponding foreign studies (see Figure 1).

At the universities students can study for lower (Bachelor's) and higher (Master's) degrees and scientific or artistic postgraduate degrees, which are the licentiate and the doctorate. In the two-cycle degree system students first complete the Bachelor's degree, after which they may go for the higher Master's degree. As a rule, students are admitted to study for the higher degree. The universities also arrange separate Master's programmes with separate student selection, to which the entry requirement is a Bachelor's level degree or corresponding studies. The extent of the Bachelor's level degree is 180 credits and takes three years. The Master's degree is 120 credits, which means two years of full-time study on top of the lower degree (see Figure 1).

The first degree in surveying after basic education studies (comprehensive school) is the cartographer. Bachelors of Science (Tech.) in Surveying are graduated from polytechnics, Masters of Science (Tech.) in Real Estate Economics and Masters of Science (Tech.) in Geomatics are graduated from Helsinki University of Technology (see Figure 1).

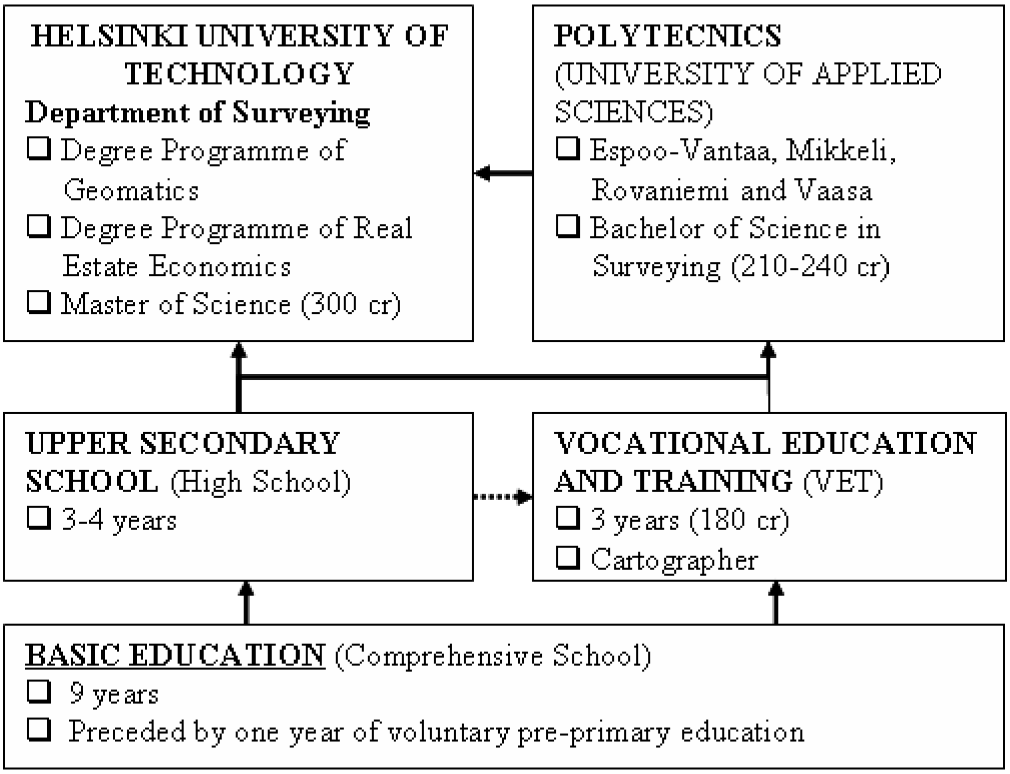


Fig. 1: The Finnish surveying education system.

Cartographers are graduated from eight vocational schools. Open posts for new students of cartography annually total in about a hundred. Bachelors of Science (Tech.) in Surveying are graduated from four Polytechnics. The annual intake is some 80. The present annual intake for the Degree Programme of Geomatics at the Helsinki University of Technology is some 40 and for the Degree Programme of Real Estate Economics some 50.

General trend in the surveying field in Finland in the 1990's was that enrolment to surveying education dropped year by year on all of the three education levels. Surveying education interested too few young people in the late 1990's and many educational institutions had less applicants than open posts. Shortage of students was especially encountered with cartographers. Figures 2 and 3 show the development of (preferential) applicant numbers to the Department of Surveying at the Helsinki University of Technology during the years 1996 to 2006.

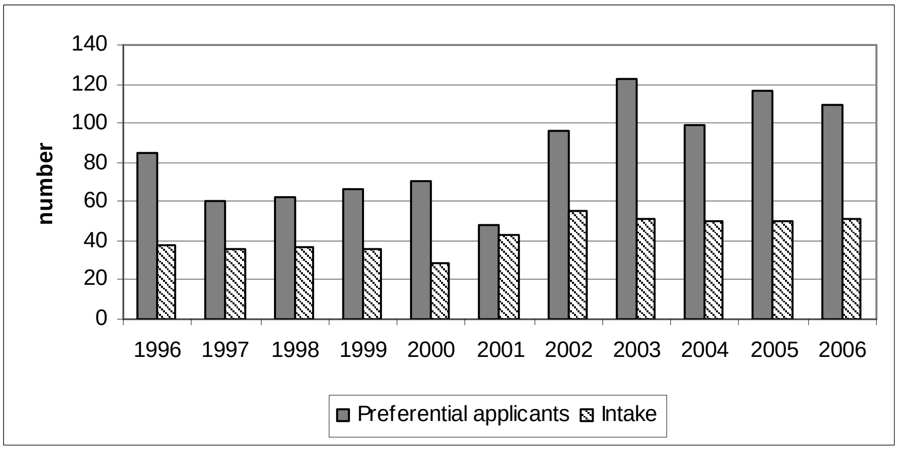


Fig. 2: (Preferential) applicants and intake to the Degree Programme of Real Estate Economics (Helsinki University of Technology)

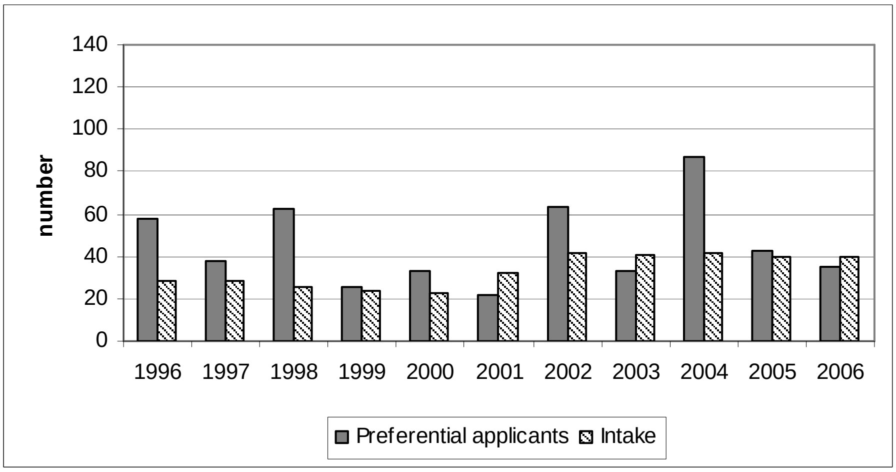


Fig. 3: (Preferential) applicants and intake to the Degree Programme of Geomatics (Helsinki University of Technology)

At the same time it was obvious that by the year 2010 about a half of the surveyors working in the late 1990’s would retire offering plenty of vacant situations. In this situation the occupational organisations, educational institutions and biggest employers in the field awoke to consider how this change of generation would be implemented successfully and how the marketing and introduction of the surveying field in comprehensive and upper secondary schools would be enhanced to make more and more young people choose surveying as future profession.

2. SURVEYING EDUCATION AT THE HELSINKI UNIVERSITY OF TECHNOLOGY

2.1 The basic model for the master's degree

In the degree structure for both the Bachelor's and the Master's Degree the courses are composed into modules, which will form the larger components of the degree: the basic studies (i.e. the general scientific studies and general studies of the programme), the subject studies, the major, and the minor. Figure 2 shows a basic model for a Master's Degree, where the student has taken the same major (A) for both the Bachelor's and the Master's Degree. The minor (B) also stays the same for both of the degrees. As previously, the student may, however, choose his/her minor (i.e. the minor modules B) from another department. The special module may be used, e.g. for advanced major studies and/or enhancing the ability for applying scientific knowledge and post-graduate studies.

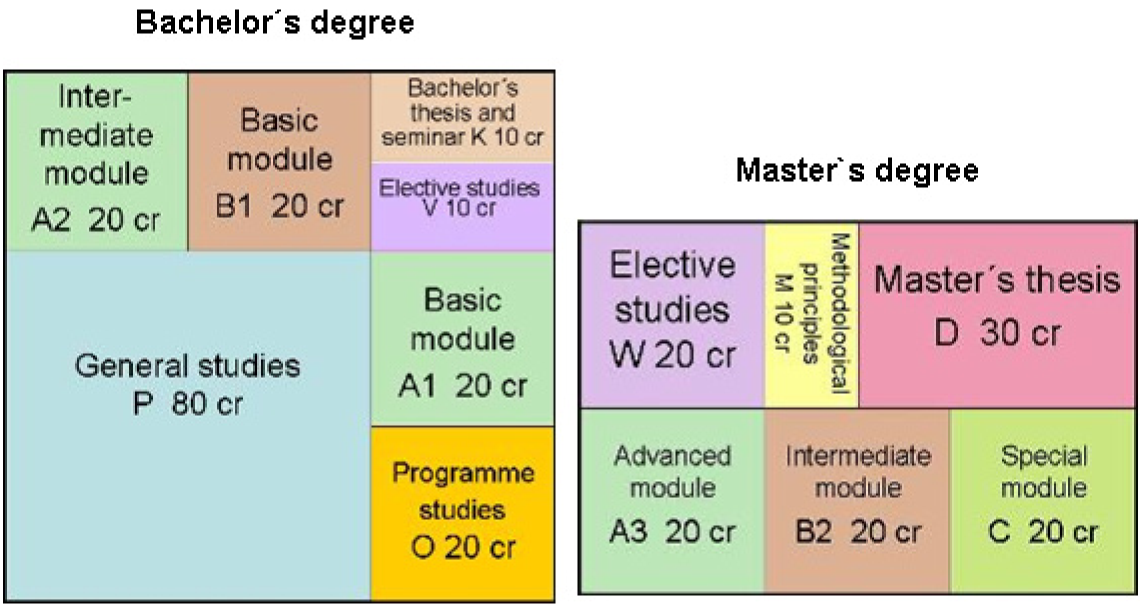


Fig. 2: The Basic model for the Master's Degree at the Helsinki University of Technology.

The Bachelor's Degree in the Helsinki University of Technology consists of general scientific studies of 80 ECTS points common to all, general studies of the programme (20 points), three Subject Studies Modules (a' 20 points), free-choice studies (10 points) and the Bachelor's Thesis (10 points). It is noteworthy that the purpose of the Bachelor's Degree is not to provide competence for working life but preparedness for education leading to a higher academic degree, continuous learning and application of the acquired knowledge in working life.

The higher degree would consist of free-choice studies worth 20 points, 10 points of scientific studies, three Subject Studies Modules (a' 20 points) and the Master's Thesis (30 points). The Subject Modules are of three stages, so the Bachelor's Degree would include one two-stage module and the Master's Degree at least one three-stage module.

2.2 The degree structure for the surveyors

In the Department of Surveying there are two Degree Programmes:

1. **Real Estate Economics**, which is divided into two options: a) Land Management and Real Estate Law and b) Real Estate and Facilities Management.

2. **Geomatics,** which is divided into two options: a) Geoinformatics and b) Surveying and Mapping Technology.

2.2.1 The degree of Bachelor of Science for the surveyors

The degree of Bachelor of Science in Technology (180 points) at the Department of Surveying thus presumes that the student normally takes the general scientific studies, general studies, Basic Module (A1) and two Subject Modules (B1/A2) and the Bachelor's Thesis. The Bachelor's Degree shall also include free-choice studies worth at least 10 points (see Figure 2).

General scientific studies (80 points) include mathematics, information technology, courses offering general preparedness for surveying studies, languages and training in both of the Programmes. In the Degree Programme of Geomatics the module also includes physics, but in the Degree Programme of Real Estate Economics physics will be substituted for basic courses on Geoinformatics, Geodesy and Photogrammetry. In addition, basic studies in the Degree Programme of Real Estate Economics will also include the basics of Urban and Environmental Planning and Design.

General studies of the programme (20 points) in Geomatics include, e.g., the basics of Remote Sensing, Photography, Photogrammetry, Geodesy and Geoinformatics and courses of Real Estate Economics worth 10 points. The module of Real Estate Economics will include basic courses on Land Management, Economics and Real Estate Law, Real Estate Valuation and Real Estate Management.

Subject Studies, Basic Module A1 (20 points) in the Degree Programme of Geomatics further includes studies on Remote Sensing, Photography, Photogrammetry, Geodesy and Geoinformatics, Geographic Data Management and GIS Software Engineering, and Theories and Techniques in Geoinformatics. The Basic Module of Real Estate Economics includes, e.g., Science of Real Estate Economics and Calculation Methods of Real Estate Economics, and Planning and Building Law.

There are two Subject Modules B1/A2 (20 points) in both of the Degree Programmes. The Subject Modules of a) Geodesy and Photogrammetry, and b) Geomatics in Geomatics, and the Subject Modules of a) Land Management and Real Estate Law, and b) Real Estate and Facilities Management in Real Estate Economics.

The students may also freely choose a Basic Module (B1) outside his/her Degree Programme instead of one of the Subject Modules. For students of Geomatics it may be, for example, Real Estate Economics, Information Technology or Imaging Technology, and for the students of Real Estate Economics it might be Surveying and Mapping Technology, Structural Engineering and Building Technology, Building Physics or Urban Planning and Design.

2.2.2 The degree of Master of Science for the surveyors

The degree of Master of Science in Technology at the Department of Surveying presumes that the student normally takes, in addition to the Bachelor's Degree, at least one Specialization Module (A3) and two Special Modules (C), free-choice studies worth 20 points, methodological studies (10 points) and the Master's Thesis (see Figures 3 and 4).

There are three Specialization Modules A3 (20 points) for the Master's Degree in Geomatics: 1) Geodesy, 2) Photogrammetry and Remote Sensing, and 3) Geoinformatics. For the Master's Degree in Real Estate Economics there are two Specialization Modules: 1) Land Management and Real Estate Law, and 2) Real Estate and Facilities Management. If the student has chosen the Basic Module B1 at the Bachelor stage, he/she may choose the Advanced Module B2 at this stage for his/her subject studies.

Special Modules C (20 points) are at the Department of Surveying meant for advanced studies after the Modules A3. Special Modules in Geomatics are 1) Geodesy, 2) Positioning and Navigation, 3) Photogrammetry, 4) Remote Sensing, 5) Cartography and 6) Geoinformatics. The Special Modules for Real Estate Economics are 1) Land Management, 2) Real Estate Economics and Valuation 3) Economic and Real Estate Law, 4) Environmental Law and 5) Real Estate and Facilities Management.

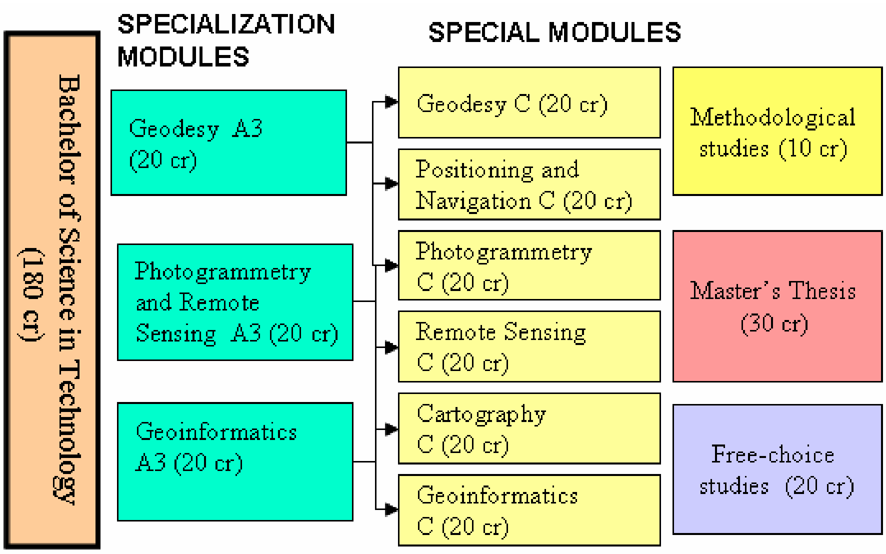


Fig. 3: The Master's Degree in the Degree Programme of Geomatics at the Department of Surveying.

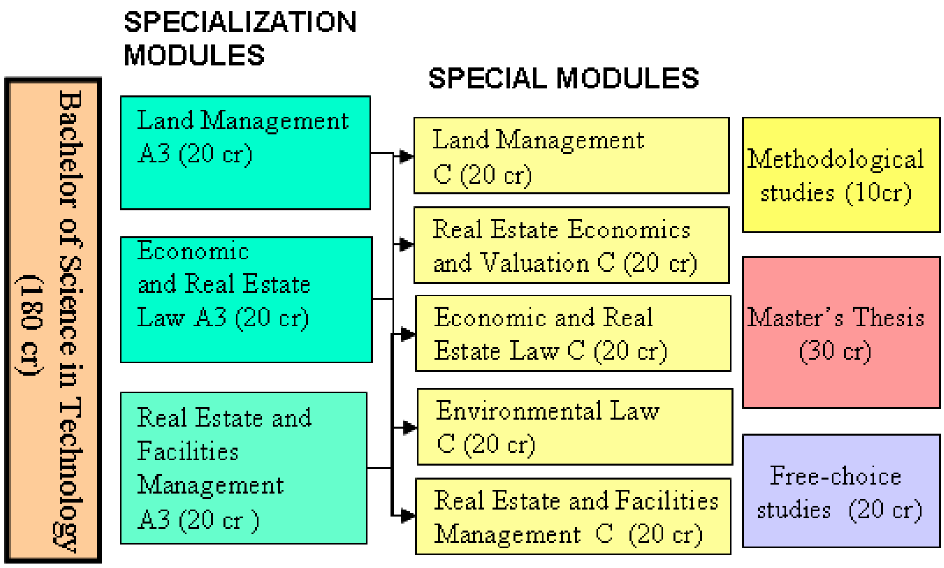


Fig. 4: The Master's Degree in the Degree Programme of Real Estate Economics at the Department of Surveying.

3. MARKETING OF SURVEYING EDUCATION

3.1 The Imago Team

In 2001 the educational institutions in field, the biggest employers, and the occupational organisations assembled to discuss what should be done to make the young ones in choice of their profession consider surveying as studies option. The discussions pointed out that the educational institutions of surveying require a sufficient number of students in order to maintain good student material and avoid future labour shortage. In this competition for students the image of the surveying field must be sound and truthful.

Imago Team was established in the spring of 2001 for promoting and marketing the various educational levels of the surveying field in the comprehensive schools and upper secondary schools. The Imago Team is a voluntary cooperative body formed by employers, educational institutions, and employee organisations ideating, planning and implementing different measures for improving the familiarity of the field, coordinating the workings of the various actors, and monitoring the development of the student situation in different educational institutions.

During its existence the Imago Team has, for instance, produced a Surveying Info File and a Surveyor CD. The Info File consists of brochures and contact information of every educational institution in the field. The CD offers basic information of the surveying studies. The File and the CD are used as supplementary material for example when the students from the Helsinki University of Technology and Polytechnics go to upper secondary schools to tell about the surveying studies and when the surveying field is presented at other occasions, for instance at the Helsinki University of Technology. Another example of the Imago Team's accomplishments is the participation in a campaign, which distributed the extra issue of the Maankäyttö magazine to all teachers of geography in the upper secondary schools (see http://www.maankaytto.fi/arkisto/mk302.php). This campaign also opened up the possibility of getting acquainted with the geographic information material to the students of the upper secondary school through the Map Site of The National Land Survey of Finland. Further, with The National Land Survey of Finland the Imago Team has promoted the surveying field and work opportunities in cooperation with the various leisure organisations moving in the terrain. For example, The Finnish Orienteering Association is one of such partners. The surveying field has been introduced to the young ones at the orienteering camps arranged by the association.

3.2 The National Land Survey of Finland

The National Land Survey of Finland as the biggest employer in the field is devoting to developing the image of their own and the surveying field by working actively in the Imago Team. Further, at the result agreements between the production units and the central administration The National Land Survey of Finland has agreed that the local surveying offices sponsor and participate in the briefings organised by the students of surveying in the local educational institutions.

As regards The National Land Survey of Finland the demand for new labour force is great in the future to replace the ones retiring. This has made the organisation also spontaneously market The National Land Survey of Finland to the young ones as a future employment. The National Land Survey of Finland has systematically published various brochures informing of the jobs and established Internet pages (www.karttakeppi.fi) telling about the various options of the surveying field to the young ones at their choice of career.

As the newest channel for familiarising the field The National Land Survey of Finland has decided to establish Internet pages in cooperation with the TAT Group during the year of 2007. These pages are directed to the teachers of geography and biology and the young ones planning their studies. (TAT Group is a communication, consultancy and training organisation owned by the Confederation of Finnish Industry and Employers, TT Trust and Confederation of Finnish Industries). These Web pages will include, for example, video presentations where experts in the surveying field tell about the various jobs and students of surveying tell about the contents of their studies.

3.3 Helsinki University of Technology and the Polytechnics

Helsinki University of Technology is the only scientific university in Finland where Masters of Science (Tech.) in Surveying are graduated. However, since jobs in the surveying field are available throughout Finland the Department of Surveying aims at informing of its educational supply nation-wide. This is accomplished on the Web pages of the Helsinki University of Technology and the Department of Surveying, and, for example, by brochures sent to all upper secondary schools. These brochures would describe the contents of the Degree Programmes of Geomatics and Real Estate Economics and give instructions on applying for a student.

Annually in the autumn and spring the Department of Surveying and the students arrange an ”open day” together with the rest of the departments in the Helsinki University of

Technology. The department and the studies options are presented to those interested. In addition to this, the students go to upper secondary schools around Finland and tell about the studies at the Department of Surveying. These direct marketing events have proven very successful. Some 20 to 40 events are annually arranged at upper secondary schools. The Department of Surveying, The National Land Survey of Finland, and the Imago Team have promoted these events, for example, by participating, covering the students' travel expenses, and producing the necessary demonstration material.

The Polytechnics also arrange similar briefing to the students at the upper secondary schools. Since 2005 students from the Helsinki University of Technology and the Polytechnics have been working in co-operation and arranged joint events at upper secondary schools.

4. CONCLUSION

The two-phase degree structure at the Helsinki University of Technology is related to the commitment of Finland and some 40 other European countries to the so-called Bologna process. The goal of the process is to clarify and harmonise the degree structures in European universities and create an internationally competitive academic education area in Europe by the year of 2010. The goal is achieved by standardising the degree structures, by adopting a uniform sizing system for the studies, by encouraging the mobility of the students, researchers and other university personnel, by enhancing the European co-operation related to the grading of studies, and by diversifying international co-operation and networking between various universities. The Helsinki University of Technology will be also in future one of the progressive Universities in Europe. Therefore this degree reform is a great challenge and an excellent opportunity for the University and for the Department of Surveying.

The surveying field in Finland is undoubtedly modernistic making in the world of geographic information. Further, some of the tasks are made in the terrain, which is interesting to many young people. The rate of employment will be very good according to the prognoses and the wage level is moderate. The surveying field is, however, rather narrow as a whole, and its problem is the fact that it is poorly known among the young ones planning their studies. In this situation the actors in the field: the employers, educational institutions and occupational organisations must work together and jointly plan actions and campaigns for encouraging the young ones to apply for a student post. The situation starts to look promising with the contribution of the Imago Team. As a result of this work the familiarity of surveying has increased among the young generation and the enrolment to various educational institutions has started to increase.

REFERENCES

Helsinki University of Technology. http://kva.tkk.fi/en/
Nuuros, R."Image and education must be remembered as well" (in Finnish Imago ja koulutusasiat muistettava myös) http://www.maanmittauslaitos.fi
Ministry of Education. http://www.minedu.fi/OPM/?lang=en
Rothe, P. Marknadsföring av lantmäteristudier i Norden. MIL 2005.

BIOGRAPHICAL NOTES

Arvo Vitikainen

Date of birth:	10 May 1951
Academic graduation:	Master of Science (Technology), Helsinki University of Technology (1976) Doctor of Science (Technology), Helsinki University of Technology (2003)
Professional career:	1976: Secretary of the Cadastral Map Project, National Land Survey 1979: Cadastral surveyor, Kaarlela Land Consolidation Office 1985: Head of Land Consolidation Office, Ylivieska Land Consolidation Office 1989: Surveying Manager and Senior Engineer, Lapland Land Survey Office, Rovaniemi
Present position:	1999: Professor of Land Management and Cadastral Sciences, Helsinki University of Technology, Institute of Real Estate Studies; Chair of the Degree Programme Committee at the Department of Surveying, Helsinki University of Technology

CONTACTS

Professor Arvo Vitikainen
Helsinki University of Technology
Institute of Real Estate Studies
P.O. Box 1200, FIN-02015 HUT
FINLAND
Tel. +358-(0)9-451 3872
Fax +358-(0)9-465 077
E-mail: arvo.vitikainen@tkk.fi

Geodesy, Cartography and Geoinformatics at the CTU Prague – history, current developments and challenges

Růžena ZIMOVÁ, Lena HALOUNOVÁ, Aleš ČEPEK, Czech Republic

Key words: education, curriculum, geoinformatics, surveying, geodesy, cartography

SUMMARY

At the Czech Technical University in Prague, there is a long tradition of master degree courses in geodesy, geodetic surveying and cartography. Fast development of information technologies in recent decades affected the composition of study plans and led to innovative steps made in recent years. The paper summarizes the history of surveying education at the CTU Prague and presents current structure of the study of both traditional Geodesy and Cartography branch and newly installed Geoinformatics, where information technologies and computer science are combined with a background of geodetic and cartographic know-how. Harmonization of curricula, development of e-learning and necessity of attracting talented students are the challenges and plans to be considered for future.

1. GEOINFORMATICS AS A SCIENTIFIC AND STUDY BRANCH

Geoinformatics and/or geomatics are modern scientific and therefore also study programs. Their definition and content is understood by specialists in a different way. Geomatics was defined in Canada in the 20th century and summarizes studying of a lot of specializations mainly of natural and technical sciences focused on their relation to the Earth. According to ISO definition geomatics is a scientific and technical interdisciplinary specialization collecting, distributing, storing, analyzing, processing, and presenting geographical data or geographical information. Large range of specializations are included and they can be applied together to create detailed, understandable image of the physical world and of our place on. Geoinformatics is a European expression for in fact the same scientific branch even though it is regarded more as applied informatics (especially in the Czech Republic) and thus focused more on theoretical tasks or limited tasks of geoinformation than the practical general interdisciplinary tool. A new study branch of Geoinformatics has been introduced as a new option within a traditional study program Geodesy and Cartography at the Czech Technical University in Prague.

2. SOME FACTS FROM THE HISTORY

When remembering the 300 years anniversary of the Czech Technical University in Prague, it may be useful to summarize the history of the study programme Geodesy and Cartography at the CTU and main milestones of its development leading to current state of curricula.

2.1 Czech Technical High School (2-years specialized education)

The tradition of an independent study branch of geodesy, geodetic surveying and cartography at the CTU Prague is more than hundred years old. At the first third of 19th century there were large cadastral surveys done on the territory of the lands belonging to the Austrian-Hungarian monarchy at that time. So called "stable cadastre" had been initiated by a strong interest of the state to establish an effective system for collection of land taxes and to cover the territory with large scale maps. Later, the fast development of agriculture and industry in the second half of the 19th century put new demands on both quality and quantity of professional cadastral measurements and map compilation. Therefore the government established a surveying study at all the universities in the former Austria-Hungary. At the Czech Technical High School in Prague, a two-year curriculum for educating surveyors was started in 1896/1897 with the aim of providing a sufficient number of professionals for work in the land registry of the state administration. Very soon after opening the two-years study it was clear that the content of study plans was not sufficient and it did not correspond with the fast technical development..

2.2 An independent Czechoslovakia – education in the College of Special Studies

The era of the Czech Technical University started in 1920/1921, soon after the emergency of an independent Czechoslovakia in 1918. With installation of a new structure of the CTU, the two-years surveying study was involved in the College of Special Studies established in 1921. Even in 1927, the debate lasting several years on the re-organisation of studies of surveying was concluded and by law extended to a period of three years.

After the Second World War, in 1946, the study of surveying engineering the CTU had been enlarged to eight semesters which allowed deepening the knowledge of mathematical and physical background and special geodetic and cartographic disciplines. At that time, most of the university institutes were concentrated to the historical building at Husova street in the Old Town, where many years ago the first lectures of Willenberg's Estates school of Engineering had started.

In 1950 the department of surveying engineering at the College of Special studies was closed. The surveying study itself was not interrupted, but for one year transferred to the Technical University in Brno. In 1952 the entire College of Special Studies was closed and remaining areas of study were transferred to other subjects (Faculty of Mathematics and Physics of the Charles University and the College of Political-Economic Sciences).

2.3 Independent Faculty of Surveying (5-years study)

An independent Faculty of Surveying was established in 1953, with a surveying study enlarged to 10 semesters. Beginning from the 3rd study year the students were divided into 3 specialisations: Geodesy, Technical land management and Cartography. Since 1954 the possibility of a distant study had been offered namely for applicants from the surveying practice enabling them to reach a specialized university education. In 1960, three faculties of the CTU – Civil engineering, Architecture and Surveying engineering were joined together into a new Faculty of Civil Engineering with corresponding study branches.

2.4 Faculty of Civil Engineering (4-years study)

All the branches of the Faculty of Civil Engineering were moved to a new campus in Prague 6 Dejvice in 1978. According to a new Law on University education in 1980 the study of surveying engineering was shortened to 4 years, only special branch of remote sensing continued with 5 years study. The era of long-time communist leadership of the country was emphasized by installing the subjects of Marxism-Leninism in a group of the state exam subjects and this situation lasted till the political changes in 1989/1990 and a new era of building-up democratic principles in the society. Beginning from 1990/1991 all the specializations of the surveying study at the CTU were changed back to 5 years. In 1994 the last group of students of the distant form of surveying study graduated.

2.5 Changes in 90ties (5,5-years study)

During the 90ties, the study of geodesy and cartography had been more and more influenced by the developments in the field of computer science and information technologies, new instruments for measurements and the tools for data capture and processing. At the end of the millennium, the study plans were adopted for duration of 11 semesters of engineering master study specialized in five professional modules. The growing demand for a skilled staff for the state institutions and private surveying firms led to the conception of the three-years bachelor study specialized in cadastre which was opened from 1994 to 1998.

2.6 Adopting the Bologna declaration, a new branch Geoinformatics

Important structural changes corresponding with Bologna declaration have been made by the academic year 2003/2004 – the study of all the programmes at the Faculty has been divided into a 4-year Bachelor degree followed by a 1,5-year of the Master degree. It means that this year, in September, we will have the first Bachelor graduates in Geodesy and Cartography at the CTU Faculty of Civil Engineering. The fast development of information technologies in recent decades has led to the decision to prepare a new study program that combines applied (geo)informatics with a background of geodetic and cartographic know-how. A new study branch of Geoinformatics within the study program of Geodesy and Cartography has been introduced since the academic year 2006/2007.

3. SURVEYING/GEOINFORMATICS STUDY AT THE CTU TODAY

3.1 Current structure of the study

At present, the Czech Technical University in Prague is structured into seven faculties while the Faculty of Civil Engineering is the biggest one concerning both the number of students, and the staff. The program Geodesy and Cartography is one four bachelor study programs at the Faculty and it involves two 4-years study branches: Geodesy and cartography and Geoinformatics. The same structure is defined for the master degree program (1.5 years), which may be followed by the doctoral program Geodesy and Cartography (3 years). The structure is presented on the Fig. 1.

3.2 Students and Staff

The specific professional courses of the study program of Geodesy and Cartography at the CTU are taught within four departments: Dept. of Surveying and Land Consolidation, Dept. of Advanced Geodesy, Dept. of Mapping and Cartography and Dept. of Engineering Geodesy (approx. 55 teaching/research staff). Usually from 80 to120 students are enrolled in one study year. For example in the year 2006/2007, almost 80 students of Geodesy and Cartography and 35 students of Geoinformatics have started the first year of the study, while the number of accepted applicants for this year was 111 for Geodesy and Cartography and 48 for Geoinformatics. The difference is represented by those who were successful in entrance exams but preferred to start at another university program. In recent years, there is an average of approx. 7 defended Ph.D. theses within the doctoral program Geodesy and Cartography.

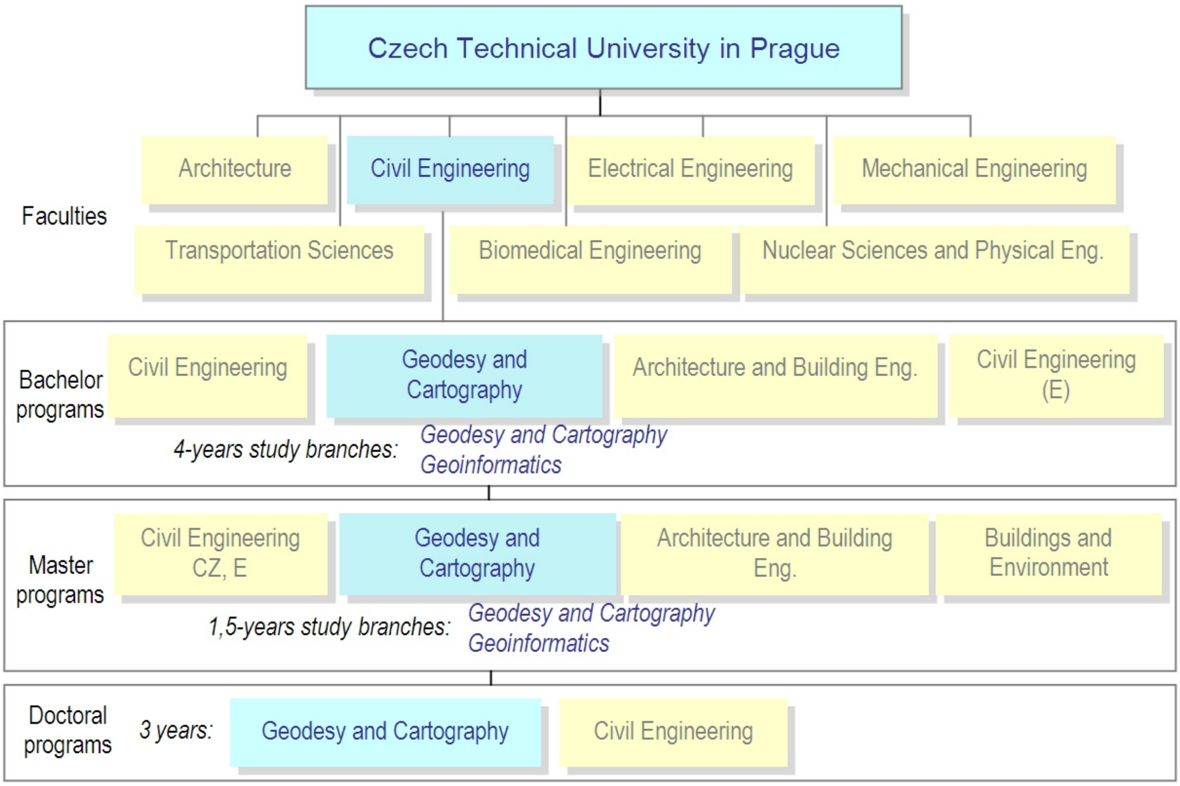


Fig. 1: The Structure of the CTU and study programs at the Faculty of Civil Engineering

3.3 Curricula

Geodesy and Cartography

The bachelor study branch Geodesy and Cartography (recommended for completion in 4 years) involves 240 credits in total, while the number of credits for specific subject is derived from the number of teaching hours per week with consideration of weight given according to the importance/difficulty of the subject.

Within this traditional study branch the students gain mathematical and physical backgrounds of geodesy and cartography as well as the practice of surveying – the techniques of gathering and processing measurements. Beginning from the 3rd study year the students may choose their specialization from one of five offered professional modules (Technical Geodesy, Theoretical Geodesy, Mapping, Photogrammetry and Remote Sensing, Cartography and GIS, Engineering Geodesy) or to compile an individual collection of courses for professional orientation (individual module). The student has to pass chosen optional courses in total for 16 credits. Current composition of the compulsory study plan can be described as follows: Specific professional courses 62 %, Computer Science, other eng. courses 10 %, Theoretical background (Mathematics, Physics, Constructive Geometry) 21 %, Languages, Humanities, Law 7 %.

The Master degree curricula (recommended for 1,5 years) involve the compulsory courses (40 credits) in Advanced Geodesy, Geodetic Astronomy and Engineering Geodesy and a wider range of selective courses in various specialisation (20 credits). The emphasis is given to the master thesis (30 credits).

Geoinformatics

A new study branch has started in the academic year 2006/2007. The bachelor study branch of Geoinformatics (recommended for completion in 4 years) involves 240 credits in total. Understanding Geoinformatics as a science that synthesizes the achievements of applied informatics with knowledge of the principles of geodesy and cartography, the conception of this new study branch at the CTU Prague is oriented on theoretical principles of geodesy and various aspects of computers and information technologies. An intensive focus on the theoretical background may attract more talented students who will be able to collaborate on scientific software projects and issues. Geoinformatics study branch also offers a wide range of optional subjects – the students have to choose the optional courses in total for 24 credits and in fact they can build themselves a final orientation of the study. Composition of the compulsory study plan is following: Specific professional courses 65 %, Computer Science, Other Eng. 9 %, Theoretical background (Mathematics, Physics, Constructive Geometry) 19 %, Languages, Humanities, Law 7 %.

The contents of Master degree curriculum (recommended for 1,5 years) is composed from the compulsory courses (30 credits), optional courses in various specialisation (30 credits) and master thesis (30 credits). Substantial part of the study will be organized in projects on various topics integrating computer and information technologies with professional issues of geodesy, GIS, remote sensing, etc.

4. SURVEYING AND GEOINFORMATICS EDUCATION IN THE CR

When seeking for education in geoinformatics at Czech universities, in principle we can find it connected with two professional specialisations: the first oriented towards geodesy, surveying and cartography and the second involved within geographical and environmental sciences. At present, special study branches on Geodesy and Cartography, Geomatics or Geoinformatics are offered by 10 universities in the CR listed in the Tab.1.

Nevertheless, individual courses oriented on practical and theoretical aspects of geoinformatics or simply GIS are introduced in much more various other study programs dealing with geography, spatial planning, architecture, agriculture, environmental science, water and forest engineering, risk management, economics, etc. The study published five years ago (Halounová and Zimová, 2002) identified more than 50 study programmes with subjects of GIS topic at 15 universities in the CR and these numbers have certainly grown since that time. More details about some of the university programs from Tab.1 are presented in some other papers of the proceedings.

University	Orientation of study	Study branches connected with
Brno University of Technology	technical	Surveying, Geodesy, Cartography
Charles University Prague	geographical	Geography, Cartography
Czech Technical University in Prague	technical/theoretical	Surveying, Geodesy, Cartography
Masaryk University Brno	geographical	Geography
Mendel Univ. of Agriculture and Forestry	technical	Forestry and Wood Technology
Palacký University Olomouc	geographical	Geography
University of Defence Brno	technical/military	Surveying, Geodesy, Cartography
University of Ostrava	geographical	Geography
University of West Bohemia Plzeň	technical	Surveying, Cartography, Mathematics
VŠB – Technical University Ostrava	technical/theoretical	Surveying, Geodesy and Cartography

Tab.1. Universities in the CR offering a specialized study in Geodesy/Surveying/Cartography, Geoinformatics or Geomatics

5. CTU – PLANS AND CHALLENGES FOR THE FUTURE

5.1 The curricula

The idea of full harmonization of the first year of the program Geodesy and Cartography with the new Geoinformatics study plan is currently under preparation. For the first study year, all the suggested changes have been approved and starting from academic year 2007/2008 both plans are going to be harmonized (with the only exception of education in technical geodesy). In the second study year the number of common subjects is limited and the curricula are going to diverge. It is clear that the curricula of the traditional branch Geodesy and Cartography and the branch Geoinformatics will have to be modified in the future according to gained experience and reached development. We also plan to open master degree study branch of Geoinformatics in English from 2008.

5.2 E-learning

The number of students enrolled in our study program hardly allows a really individual approach. Therefore the method of e-learning is more and more going to be not only an interesting alternative for the classical university teaching process but just a must for us. In our traditionally conservative academic society not all colleagues are still aware of this fact.

5.3 Attracting students

Compared to university programs (humanities, law, economics, etc.), technical universities usually face the problem of attracting larger number of excellent and very good students. This is certainly the problem of the CTU Faculty of Civil Engineering and surveying education, too. In our specialization it may be connected also with the fact that graduates in traditional surveying are often underpaid on our labour market.

The students of the Geodesy and Cartography program come generally from two main sources. The first one is a secondary school specialized in practical surveying – the applicants have already got a good knowledge in the professional skills nevertheless for some of them the background theoretical subjects (as mathematics, physics, adjustment calculus, informatics) play a role of an input filter.

Another major part of the students come from general secondary schools where the education process is understood in fact as a preparation for university studies. But the quality of various secondary schools may be quite different. As follows from the statistics recorded at our faculty the average quality of our students has fallen significantly during recent years. We believe that the way of offering more courses on information technologies and related branches like GIS and geoinformatics, i.e. the disciplines being in force on the labour market at present, can more successfully address the category of very good and talented students.

5.4 Structured study for mobility of students

According to the Bologna process, we should also try to attract bachelors from other universities to our master degree programs. Here we face a technical problem stemming from the fact that our bachelor program is one year longer than it is usual at the other Czech universities. The original idea of 4-years bachelor program was connected with the demand of necessary education of civil engineers as a condition for European acceptance of professional education. Our former plans were to prepare our geodesy and Cartography bachelors fully for the work in the cadastre and we supposed that the bachelor degree would be acceptable for granting an official engineering authorization in cadastral surveying, but this was not approved in negotiations with the Czech Office for Surveying, Mapping and Cadastre.

For the future we discuss an option of opening a parallel 2,5-year master program for the graduates from 3- years bachelor programs from other universities. This situation is similar in all the study programs of the CTU Faculty of Civil Engineering and the decisive conception will have to be approved by the university scientific board.

REFERENCES

[1] ČEPEK, A., MERVART, L., KOPEJSKA, J. (2007). Motivace pro studium geoinformatiky. In *Sborník sympozia GIS Ostrava 2007* . Eds. J. Horák, P.Děrgel. VŠB – TU, 28.-31.1. 2007, Ostrava.

[2] ENEMARK, S. (1998): Review of Educational Needs, Consultancy to the Czech Office for Surveying, Mapping and Cadastre, EU Phare Land Registration Project, Project No. CZ 94402-02, February 1998.
[3] FRAGNER, B., VEJRAŽKA, F. (Eds.)(2002). *Česká technika / Czech Technical University*. ČVUT v Praze, 2002, 181 p. ISBN 80-01-02663-9
[4] HALOUNOVÁ, L., ZIMOVÁ, R. (2002). Přehled studijních oborů k problematice GIS na vysokých školách v ČR In Sborník konference MIS/UDMS (Městské informační systémy/Urban Data Management Symposium), 1.- 4.10. 2002, Praha.
[5] JEŘÁBEK, O. (1982). Vývoj samostatného zeměměřického studia na ČVUT v Praze. *Geodetický a kartografický obzor*, Vol. 28/70, No.5/1982, p. 130-134.
[6] MERVART, L., ČEPEK, A. (2006). Geoinformatics at the CTU in Prague. In *Geoinformatics,* Faculty of Civil Engineering, CTU Prague, p. 4-11, 2006. ISSN 1802-2669
[7] MŠMT: Akreditované studijní programy vysokých škol. http://www.msmt.cz/
[8] POTŮČKOVÁ, M. (2006). Geoinformatics at the CTU in Prague. In *Geoinformatics*, Faculty of Civil Engineering, CTU Prague, p. 34-43, 2006. ISSN 1802-2669

BIOGRAPHICAL NOTES

Růžena Zimová is a lecturer at the Department of Mapping and Cartography, CTU Prague, Faculty of Civil Engineering. Work experience: Geophysical Institute of the Czech Acad. Sci., Dept. of Seismology (1981-1992). Membership: Cartographic Society of the CR, association Nemoforum. Teaching and research activities: cartography, digital cartography, ancient maps analysis, coordination of geoinformation, spatial data infrastructures.

Lena Halounová is an Associate Professor at Czech Technical University in Prague as well as the head of the Remote Sensing Laboratory, at the Department of Mapping and Cartography, Faculty of Civil Engineering, CTU. Chairperson of the Czech society of ISPRS. She teaches remote sensing, image data processing, and GIS and uses these technologies in a variety of environmental assessment projects.

Aleš Čepek has been professor of geodesy since 2003, and has worked since 1992 at the Department of Mapping and Cartography, Faculty of Civil Engineering, CTU Prague, Czech Republic. He started his professional career at the Research Institute of Geodesy, Topography and Cartography (VÚGTK), Zdiby (from 1980 to 1991), where he worked on research projects, programming, analysis and implementation of data structures for cadastral programs, and was a co-author of programs for adjustment and analysis of geodetic networks; later he worked on geodetic observatory observations with circumzenithal (astrolab), a project for estimating the parameters of a local quasigeoid. At present he is conducting research in the field of applications of XML and object-oriented processing of geodetic and cartographic data.

CONTACTS

Ing. Růžena Zimová, Ph.D., Doc. Ing. Lena Halounová, CSc., Prof. Ing. Aleš Čepek, CSc.
Czech Technical University in Prague
Faculty of Civil Engineering, Department of Mapping and Cartography
Thákurova 7, 166 29 Prague 6, The Czech Republic
Email: zimova@fsv.cvut.cz, lena.halounova@fsv.cvut.cz, cepek@fsv.cvut.cz
Web site: http://gama.fsv.cvut.cz/wiki/index.php/GeoWikiCZ_in_English

Where May Geospatial Education at Czech Universities Head in the Future?

Vladimir ŽIDEK, Czech Republic

Key words: geospatial education, GIS, remote sensing, geoinformatics, university courses, commercial SW, non-commercial SW, open-source/free SW

SUMMARY

Information on location of objects in the space helps to manage real-world problems. Contemporary geospatial technologies (especially geographic information systems and image processing systems) provide users with tools that are constantly being refined and becoming ever more complicated. Reduced direct tuition and increased individual study by students themselves becomes general trend. The author presents his experience in GIS and remote sensing teaching at the Department of Geoinformation Technologies at the Mendel University, Brno, and gives his views on the possible directions that future development may take.

1. INTRODUCTION

Contemporary information and communication technologies develop very rapidly, not only in theory but also in practice. Geographic information systems (GIS) are a typical example. They provide not only information on location of objects in the space and on their attributes, but they can also answers various geospatial questions, analyze large data files and offer a support in decision processes. GIS training helps students develop computer literacy, critical thinking, analytical approaches to problem solving, and communication and presentation skills. GIS also help people to understand and to manage real-world problems using data processing and analysis. Furthermore, digital processing of remotely sensed data enables users to maintain geospatial information up-to-date. At universities, it is sometimes difficult to keep up with all the progress in a geospatial domain.

2. HISTORY OF GEOSPATIAL EDUCATION AT FACULTY OF FORESTRY AND WOOD TECHNOLOGY OF MENDEL UNIVERSITY BRNO

In 1990, when I started working for the Department of Surveying at the Faculty of Forestry, Mendel University Brno, the only course included in the Forest Engineering curriculum was Surveying (2 semesters in the second year of study) that included also several lectures in Photogrammetry.

As foresters (not excepting university teachers) are generally quite conservative people, new ideas, new geospatial concepts and new courses had to be introduced gradually. In the academic year 1990/1991 lectures in Remote Sensing were incorporated into the Photogrammetry block of the Surveying course. In 1991/1992, Remote Sensing becomes an optional course. In 1992/1993, the course Remote Sensing involved several Geographic information systems (GIS) lectures. In 1995/1996 GIS become an independent one-semestral compulsory course. Reflecting changes in the curriculum, first proposal to include geoinformatics or geomatics in the name of the Department was offered to the Dean of the Faculty in 1994. Nevertheless, 13 years elapsed before the proposal was realised and the Department of Surveying (founded 1921) became the Department of Geoinformation Technologies (since January 2005).

At the beginning of teaching the geospatial digital data processing, practical computer laboratory exercises in Remote Sensing and GIS were realized at computer labs of the Department of Computing Technology; later at 10-seat labs of the Department of Forestry and Wood Economics, where students worked in pairs. In 2000/2001, owing to a grant received from the Fond of Higher Education Development (of Ministry of Education), 11 computers were bought and an old exercise classroom of the Department of Surveying has been rebuilt into a modern computer laboratory. In 2003/2004, new grant from the Fond of Higher Education Development enabled to increase the lab capacity to 20-seats and to buy a set of 5 Trimble Pathfinder Pocket/Reckon GPS stations and a Trimble GeoXT GPS station for field works.

Bologna process has started at the Faculty in 2001/2002; in 2004/2005 new bachelors in Forestry and in Landscaping graduated. Since than the compulsory GIS course is being taught at a Bachelor level, and approximately 250 students per year are enrolled. Optional courses at the Bachelor level include Remote Sensing Fundamentals, Digital Terrain Models, Digital Photogrammetry and Visualisation, Digital Cartography (ArcGIS), Digital Cartography (Topol) and GIS Fundamentals (in English, for foreign Socrates students).

At a Master level, in Landscape Engineering study program (Integrated Landscape Utilization branch) compulsory courses Remote Sensing and Integrated GIS Utilization are being taught. Students can complement their curricula by optional courses mentioned above.

At a Doctoral level, students have had the possibility to study geoinformatics as a specialization in a framework of the “Forest management” study since 1996. Nevertheles, as a component part of this study was the “Forest management” exam, only few interested students from other faculties or universities could be practically enrolled. To overcome this issue, a new doctoral study program “Applied Geoinformatics” has been proposed to the Ministry of Education and it has been accredited since 2007. Students can focus on the use of geoinformatics in forestry, in agriculture, in economics and in territorial and regional decision support.

3. COMMERCIAL, NON-COMMERCIAL AND OPEN-SOURCE/FREE SOFTWARE FOR GIS AND REMOTE SENSING

The user of GIS and image processing software should master the use of many tools to make the best of such systems. GIS and remote sensing teaching at universities must therefore include practical exercises in computer laboratories. SW (SW) for this training can be divided into three groups, differentiated by their data processing abilities, but mostly by price (more about price later). In this context, we can refer to commercial, non-commercial and open-source/free SW. I consider as commercial SW that is created mainly for profit and whose user has no way of examining the source code. A SW that is not created primarily for profit, but again one where the user generally cannot examine the source code, can be considered as non-commercial. Open-source/free SW is SW where the source code is available, the user can get particular products for free and the possibility exists to develop them further.

3.1 Commercial Software

3.1.1 GIS Software

A typical representative of this group is a vector oriented American system ArcGIS, produced by the Environmental Systems Research Institute, ESRI. (Laura and Jack Dangermond established the ESRI at Redlands, California, in 1969.) The oldest version of this SW, Arc/Info for mini-computers has been launched in 1982; PC Arc/Info has been launched in 1986. Since then this SW has been enriched with many tools for spatial data processing and ArcGIS desktop represents today a complex and integrated system of GIS products. There is a wide selection of literature on the product, see e.g. ESRI (1999, 2005, 2007a) and web information not only in English (ESRI 2007b) but also in Czech (ArcData 2007a) and other languages. The Czech company, ArcData, which distributes ArcGIS in the Czech Republic, offers users a library of technical publications (ArcData 2007b).

Several extensions of ArcGIS desktop, e.g. ArcGIS Spatial Analyst, ArcGIS 3D Analyst, ArcGIS Network Analyst, ArcGIS Business Analyst enhance analytical possibilities of this SW. Web services are provided by ArcGIS servers and ArcPad can be used for field work. For basic practical exercises in a computer labs with 15-20 seats products ArcView or ArcEditor can be used, offering students a variety of tools for creating, editing and analysis of geospatial data.

Although ArcView represents a basic version of the ArcGIS product, the system is rather too complicated for an inexpert user. If you want to work successfully, you need to use the interface of three applications. ArcMap enables map editing and analysis, ArcCatalog enables data management and ArcToolboxes provide transformation, statistical and other tools. In addition, it is possible to use a graphic interface, ModelBuilder, for constructing geospatial models. Its complexity may be intentional on the part of its makers, as without professional training few users can use the system effectively. The professional training often needed is not cheap, either – in Czech Republic, where the average monthly wages is approximately 21000 CZK (Czech crowns), a two-day basic training course for ArcGIS v. 9 costs about 10700 CZK. For those who are interested, courses are offered by ESRI Virtual Campus (ESRI 2007c). While you generally have to pay, some are free.

In the Czech Republic, one of the strengths of ArcGIS is that it is widely used by government and other official agencies. According to the ArcData Company (Melounova 2006), ArcGIS is the leading GIS in the Czech Republic. From the point of view of a student or a private user, its price constitutes a drawback (see Chapter 4, Table 1), as only a few such people can afford to buy ArcView or ArcEditor (not to mention ArcInfo) with the necessary extensions.

3.1.2 Software for Remote Sensing

Similar situation mentioned in GIS software sub-chapter exists also in offer of remotely sensed data processing programs.

Main commercial products usually available at multi-seat labs of universities are represented by a software package Erdas Imagine Professional 9.0 of an American company Leica Geosystems Geospatial Imaging and a software package Geomatica 10 of a Canadian company PCI Geomatics. Both these systems are very suitable for teaching and research of remotely sensed data processing. (Students of our Department use the networked version of Geomatica 10.) Erdas has a better integration with ESRI product, while Geomatica disposes the best set of raster analytic operations.

Less common at Universities (because of price), but very powerful software for image classification is Definiens Professional/eCognition, produced by a German company Definiens. This software does not classify single pixels, but first segments the image into spectrally homogenous objects. With multi-resolution image segmentation providing a hierarchical network of image objects, users get a multi-scale, real-world view. Additional information that can be derived from image objects, e.g. shape, texture, area, context may be used for classification. Knowledge-based classification of eCognition enables the user to formulate concepts and knowledge about the relevant image content and to use this knowledge to process contextual information. The knowledge base is created by means of inheritance mechanisms, concepts and methods of fuzzy logic, and semantic modeling. This way eCognition can recognize some characteristics that are typical for a human visual inspection. Both Erdas and Geomatica well cooperate with eCognition.

3.2 Non-commercial Software

A typical representative of this group is a raster oriented American SW for GIS and image processing called Idrisi. (Abu Abd Allah Muhammed al-Idrisi, 1100-1166, was an important Muslim geographer.) Idrisi SW has since 1987 been developed at Clark Laboratories for Cartographic Technology and Geographic Analysis (Clark Labs) at Clark University, Worcester, Massachusetts, USA (Clark Labs 2007a). The man mainly responsible for developing and making Idrisi is Prof. Ronald Eastman (Eastman 2006a). Idrisi was developed from the beginning as a not-for profit SW and initially the system did not have any license protection. It therefore spread quite quickly around the world and today it has users in more than 175 countries – at universities and among professionals in a wide range of industries. Environmental managers and researchers thus benefit today from an unsurpassed range of geospatial tools. For these reasons Idrisi belongs to the mostly expanded raster GIS.

Tutorials have also been developed for the Idrisi project. The SW is distributed with a set of data and exercises that familiarize users with the most important ways of image data processing and with GIS fundamentals (Eastman 2006b). In cooperation with UNITAR (United Nations Institute for Training and Research) Clark Labs edit thematic workbooks (Clark Labs 2007b) that acquaint user with particular analytical techniques and provide real digital data sets for use as practical exercises. As well as a network of resellers the Idrisi project has established a network of Idrisi Resources Centers (Clark Labs 2007c) which give information to the public, provide training courses, organize user meetings and support the system at a regional level.

Idrisi is quite a strong analytical tool. The basic menu enables access to more than 250 modules for the analysis and display of digital geospatial data. Command are simpler than in ArcGIS, as the user controls all the modules from a single interface and does not need additional extensions.

In its latest 15th version the software includes also innovative tool for landscape modeling – Land Change Modeler for Ecological Sustainability. This facility can be effectively applied for land cover change assessment, change prediction, assessment of its impacts on habitat and biodiversity, and also for the exploration of planned interventions.

The great advantage of Idrisi is that, besides being a high-power GIS, it also allows remotely sensed data processing and analysis. According to Clark Labs web pages, „Idrisi Andes“ offers the most extensive set of GIS and Image Processing tools in the industry in a single, affordable package and contains the most extensive palette of image data classifiers. Some of them belong to automated machine learning procedures and integrated neural network solutions. These approaches do not depend upon restrictive assumptions about the underlying character of class distributions and are capable of learning complex patterns with limited data.

In our country Idrisi is widely used for teaching and research at universities, but seldom in a professional practice. The price of Idrisi is comparable to ArcGIS; see Chapter 4, Table 1. Nevertheless, if we consider that Idrisi is a complete GIS software package containing also tools for remotely sensed image data processing and analysis, and if we keep in mind that the user working with ArcGIS usually needs also several extensions, the Idrisi seems, according to price, more available to students and private users.

3.3 Open-Source/Free software

The main representative of this group is a hybrid (raster/vector) GIS GRASS. GRASS (Geographic Resources Analysis Support System) has been developed since 1982 for American Army needs. Several federal agencies, universities and private companies participated on the making.

The main maker of the system, the Construction Engineering Research Laboratory (CERL) of the American Army finished GRASS version 4.1 in 1992 and till 1995 produced five upgrades. CERL also created a kernel of the system for version 5. Up to this version the GRASS has been raster oriented, since version 6 it can be considered a hybrid system. In the end of eighties of last century, CERL gave the complete software package including source codes to public disposition. GRASS runs natively under GNU/Linux operation system, but it can work also under UNIX, Mac OSX, MS-Windows and other platforms.

In 1999, Markus Neteler (University of Hanover, Germany) and Bruce Byars (Baylor University, Texas, USA) established a GRASS Development Team, which coordinates activities related to GRASS development and research at an international level. The basic user interface still remains command-oriented, but it is also possible to use a graphic user interface (GUI) independent of a platform.

As GRASS is open-source/free SW published under GNU General Public License (GNU 2007), its users are not limited by price and the program is readily accessible to students and private users. This is its indisputable advantage, compensating to a certain extent for some of its disadvantages, but mainly for the fact that the prompt control is less than ideal and data editing more complicated. (It is understandable that commercial companies, with their coordinated teams of programmers, can work on creating well-functioning and cohesive tools better than a group of individuals operating via the internet.)

GRASS SW, like Idrisi, provides not only GIS tools, but also a complete set of operations for processing satellite images and aerial photographs. Neteler and Mitasova (2004) published a useful and detailed textbook on GRASS. There is also a very good user support for GRASS on the internet, e.g. GRASS (2007a, 2007b), also in Czech language (GRASSwikiCZ 2007). Internet tutorial for version 4.0 can be found on GRASS (2006). Landa (2005) has produced a set of GRASS exercises in the Czech language.

The main advantage of GRASS consists in fact that it is an open-source/free SW easily available and that its user community grows rapidly. But, in spite of all this, GRASS is little used by commercial and administrative organizations (usually it is utilized only at places where are GRASS enthusiasts). This constitutes the main disadvantage of GRASS, at least in the Czech Republic.

Quantum GIS, QGIS (QGIS 2007) is another open-source/free GIS SW distributed and supported via the internet. Like GRASS, QGIS runs on Linux, Windows and other platforms and can work with vector, raster and database formats. Commercial support and training are available, e.g. from Hanover-based Gesellschaft für Datenanalyse und Fernerkundung (GDF). A similar service is offered by the HUGIS Company in Zurich, Switzerland. QGIS tutorials can be also found on the internet, cf. Sutton (2006) and others.

For remotely sensed data processing, MultiSpec – an open-source/free multispectral image data analysis system can be used. MultiSpec is being developed at Purdue University, West Lafayette, Indiana, by David Landgrebe and Larry Biehl from the School of Electrical and Computer Engineering. MutliSpec capabilities provide a state-of-the-art competence to analyze moderate and high dimensional multispectral data sets of practical size. All versions are available via the internet (Multispec 2007a), along with substantial additional documentation listing its capabilities in more detail and providing tutorial exercises in its use.

MultiSpec tutorials/exercises (MultiSpec 2007b) comprise display and inspection of image data, image enhancement, unsupervised classification (cluster analysis), supervised classification, combining separate image files into a single multispectral image file, overlay ArcGIS shape files on image windows.

4. PRICE RELATIONS

Prices of the SW packages that I have mentioned (valid for the Czech Republic in 2006) are given at Table 1. All prices are based on producers' list prices and invoices that I have received during the summer and autumn of 2006.

Table 1. Price of SW packages for GIS and Remote Sensing

ArcGIS (ESRI)	
ArcView 9 concurrent use Lab Kit Pak (25 seats)	$1200, further support $300
ArcEditor 9 concurrent use Lab Kit Pak (25 seats)	$3000, further support $600
ArcGIS Spatial Analyst Lab Kit Pak (25 seats)	$600, further support $50
ArcGIS 3D Analyst Lab Kit Pak (25 seats)	$600, further support $50
ArcGIS Geostatistical Analyst Lab Kit Pak (25 seats)	$600, further support $50
ArcGIS Network Analyst Lab Kit Pak (25 seats)	$600, further support $50
ArcGIS Survey Analyst Lab Kit Pak (25 seats)	$600, further support $50
Stereo Analyst a Image Analysis Lab Kit (25 seats)	$1725, further support $225
ArcView 9 single use	$300, further support $300
ArcGIS Spatial Analyst single use	$600, further support $50
ArcGIS 3D Analyst single use	$600, further support $50
Erdas (Leica Geosystems)	
Erdas Imagine Professional 9.0 (20 seats university license)	$13365
Geomatica (PCI Geomatics)	
Geomatica 10 Total Educational Suite (20 seats + 1 single license)	$11565
eCognition (Definiens)	
Definiens Professional 5.0 (single educational license)	€3450
Idrisi (Clark Labs)	
Idrisi Student Lab Kit (15 seats)	$2750.00
Idrisi Campus License	$6500.00
Idrisi Campus Maintenance License	$3250.00
Idrisi Single Seat Academic License	$675.00
Idrisi Single Seat Student License	$295.00
Idrisi Student Starter	$95.00

GRASS, QGIS, MultiSpec (Open-Source/Free SW)
Price unimportant. Binary codes enabling SW installation and source codes enabling SW modification can be freely downloaded from particular addresses, e.g. http://grass.itc.it/ for GRASS, http://qgis.org/ for QGIS and http://cobweb.ecn.purdue.edu/~biehl/MultiSpec/ for Multispec.

5. CONCLUSION: WHERE MAY GEOSPATIAL EDUCATION AT CZECH UNIVERSITIES HEAD IN THE FUTURE

Reduced direct tuition and increased individual study by students themselves becomes general trend not only at the Mendel University of Agriculture and Forestry, Brno, but at many other universities in our country. This process inevitably requires more individual work by students.

Consequently, if we want to set our students individual GIS projects, we have to understand that at a minimum one or other of the following two conditions is met:

- Students must have satisfactory access to necessary computer equipment, including specific SW, so that opportunities for individual work are not limited. Currently such opportunities, at least at most Czech universities, are generally not possible.
- Cheap SW or free SW (freeware) must be available to students to enable them to process given tasks/problems, not only at university work places, but also at home on private computers.

At the Department of Geoinformation Technologies of the Mendel University, we presently use for basic laboratory GIS exercises SW packages of all three above-mentioned groups, i.e. ArcGIS, Idrisi and GRASS. Tutorial material (Zidek et al. 2005) and the Department's web pages (DGI 2007) provide necessary educational support. In remote sensing lab practicals, programs Idrisi, Geomatica, GRASS and MultiSpec are used.

For individual projects, aimed at demonstrating how students deal with given problems, we lack the necessary computer lab capacity, although several university labs can be made available for specific purpose. It is clear that, given these conditions, such projects are impossible without homework of some extent. But how can a student work at home, when he or she has a computer, but not the necessary SW?

From all this it follows that if we want students to produce meaningful individual project work and if we want to convince them that they can also later put to effective practical use what they have learned during their study, we need to give much more attention to GRASS and other open-source/free SW. I believe that more extensive use of the open-source/free SW is the way forward, and that this will happen before long – and not only in a geoinformation domain. For example, free office suite (Open Office 2007), compatible with all other major office suites, is free to download, use, and distribute. I am deeply convinced that practical education at our universities should as soon as possible reflect this existing trend.

REFERENCES

ArcData (2007a), http://www.arcdata.cz/SW/esri .
ArcData (2007b), http://www.arcdata.cz/publikace/knihovna .
DGI (2007), mapserver.mendelu.cz .
Clark Labs (2007a), http://www.clarklabs.org/ .
Clark Labs (2007b), http://www.clarklabs.org/products/unitar-workbooks.cfm .
Clark Labs (2007c), http://www.clarklabs.org/resources/resource-centers.cfm .
Eastman, J. R. (2006a), Idrisi Andes. Guide to GIS and Image Processing. Clark Labs, Clark University, Worcester, Ma.
Eastman, J. R. (2006b), Idrisi Andes. Tutorial. Clark Labs, Clark University, Worcester, Ma.
ESRI (1999): Pracujeme s geografickým informačním systémem ArcView GIS. Computer Press, Brno.
ESRI (2005), Getting to know ArcGIS desktop. ESRI Press, Redlands, Ca.
ESRI (2007a), ESRI Press catalog, http://gis.esri.com/esripress/display/index.cfm) .
ESRI (2007b), http://www.esri.com/ .
ESRI (2007c): http://training.esri.com/gateway/index.cfm?fa=catalog.gateway .
GNU 2007, http://www.gnu.org/ .
GRASS (2006), http://grass.itc.it/gdp/imagery/grass4_image_processing.pdf .
GRASS (2007a), http://grass.itc.it/ .
GRASS (2007b,http://grass.itc.it/gdp/tutorials.php .
GRASSwikiCZ (2007), http://grass.fsv.cvut.cz/wiki/index.php/GRASSwikiCZ .
Landa, M. (2005), http://gama.fsv.cvut.cz/wiki/index.php/Zpracov%C3%A1n%C3%AD_obrazov%C3%BDch_dat#cvi.C4.8Den.C3.AD .
Melounová, E. (2006), ArcData Praha, personal communication.
Multispec (2007a), http://cobweb.ecn.purdue.edu/~biehl/MultiSpec/
Multispec (2007b), http://cobweb.ecn.purdue.edu/~biehl/MultiSpec/tutorials.html
Neteler, M., Mitasova, H (2004), Open Source GIS: A GRASS, 2. edition. Kluwer Academic Publishers/Springer, Boston, Dordrecht.
Open Office (2007), http://www.openoffice.org/
QGIS (2007), http://qgis.org/ .
Sutton, T., (2006), http://blog.qgis.org/?q=node/10 .
Zidek V., Cepický J., Klimanek M., Mikita T., Sumbera S., Bortlova P., Misaková L. (2005), Creation and analysis of digital spatial data (In Czech: Vytváření a analýza digitálních prostorových dat). Mendel University, Brno, 66 pp.

BIOGRAPHICAL NOTES

Prof. Vladimir Židek graduated (1968) in Forestry from Mendel University of Agriculture and Forestry, Brno. He obtained a Ph.D. (CSc.) degree in Cartography - specialisation Remote Sensing from the Czechoslovak Academy of Sciences, Prague in 1991 and a DESS (Diplome d´Etudes Supérieures Specialisées) in Télédétection & SIG (Remote Sensing & GIS) from Université Pierre et Marie Curie, Paris 6 in 1994. In 2004 he was named the first Professor in Geoinformatics in the Czech Republic. Since 1990 he works at the Mendel

University of Agriculture and Forestry Brno, Faculty of Forestry and Wood Technology, Department of Geoinformation Technologies, in positions: Senior Lecturer (1990-1993), Associate Professor (1993-2003), Head of the Department (1995-2006), Vice-Rector for International Affairs and Informatics (1997-2000), Professor (2004-present). Principal professional interest: The use of remote sensing and GIS for monitoring of renewable natural resources.

CONTACTS

Prof. Vladimir Židek
Mendel University of Agriculture and Forestry Brno
Department of Geoinformation Technologies
Zemedelska 3
61300 Brno, Czech Republic
Tel. +4205 4513 4014-5
E-mail: mailto:zidek@mendelu.cz
http://mapserver.mendelu.cz/en/index.html